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THE

SOLAR SYSTEM.

PART I.

"With what an awful world-revolving power
Were first the unwieldy planets launch'd along
Th' illimitable void! Thus to remain
Amid the flux of many thousand years,
That oft has swept the toiling race of men
And all their labor'd monuments away,
Firm, unremitting, matchless in their course;
To the kind temper'd change of night and day,
And of the seasons ever stealing round,
Minutely faithful."

THOMSON.

REVISED BY DANIEL P. KIDDER

New-York:

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THE SOLAR SYSTEM.

INTRODUCTION.

Of all the sciences which are the subject of human study and investigation, Astronomy must be admitted to be the most interesting and sublime. It teaches us the motions, the magnitudes and distances of the heavenly bodies—their diversified phenomena, the laws by which they are directed in their varied movements, and the grand designs they are intended to fulfill in the vast system of the universe.

The objects with which this science is conversant are so grand and marvelous—surpassing everything that could have been imagined in the infancy of science—that they tend to enlarge the field of human contemplation, to expand to an indefinite extent the conceptions of the human intellect, and to arouse the attention and excite the admiration even of the most incurious and uncultivated minds. The vast magnitude of the heavenly bodies, so far surpassing what could be conceived by their appearance to

the unassisted eye; their incalculable numbers; the immense velocity of their motions, and the astonishing forces with which they are impelled in their career through the heavens; the attractive influence they exert upon each other, at the distance of hundreds of millions of miles; and the important ends they are destined to accomplish in the universal empire of Jehovah; present to the human imagination a scene, and a subject of contemplation, on which the soul of man might expatiate with increasing wonder and delight, during the indefinite series of ages.

Even to a common observer the heavens present a sublime and elevating spectacle. He beholds an immense concave hemisphere of unknown dimensions, surrounding the earth in every region, and resting as it were upon the circle of the horizon. From every quarter of this vast expanse—when the shades of night have spread over the earth—he beholds numerous lights displayed, proceeding onward in solemn silence, varying their aspects at different seasons, moving with different degrees of velocity, shining with different degrees of splendor, and all calculated to inspire admiration and awe. Wherever he travels abroad, either on the surface of the land or of the ocean, the celestial vault still appears encompassing this lower

world; and, after traveling thousands of miles, it appears still the same, and seems to make no nearer an approach than when the journey commenced. While contemplating this wonderful expanse with the eye of reason and imagination, the mind is naturally led into a boundless train of speculations and inquiries. Where do these mighty heavens begin, and where do they end? Can imagination fathom their depth, or human calculations, or figures, express their extent? Have the highest created beings ever winged their flight across the boundaries of the firmament? Can angels measure the dimensions of these heavens, or explore them throughout all their departments? Is there a boundary to creation beyond which the energies of Omnipotence are unknown, or does it extend throughout the infinity of space? Is the immense fabric of the universe yet completed, or is Almighty Power still operating throughout the boundless dimensions of space, and new creations still starting into existence?

Such views and inquiries have a tendency to lead the mind to sublime and interesting trains of thought and reflection, and to afford scope for the noblest energies and investigations of the human intellect. A serious contemplation of the heavens opens to the mental eye a

glimpse of orbs of inconceivable magnitude and grandeur, and arranged in multitudes which no man can number, which have diffused their radiance on our world during hundreds of generations. It opens a vista which carries our views into the regions of infinity, and exhibits a sensible display of the immensity of space, and of the boundless operations of Omnipotence: it demonstrates the existence of an eternal and incomprehensible Divinity, who presides in all the grandeur of his attributes over an unlimited empire. Amidst the silence and the solitude of the midnight scene, it inspires the soul with a solemn awe, and with reverential emotions; it excites astonishment, admiration, and wonder, and has a tendency to enkindle the fire of devotion, and to raise the affections to that ineffable Being who presides in high authority over all the movements of the universe. It teaches us the littleness of man, the folly of pride and ambition, and of all that earthly pomp and splendor with which mortals are so enamored—and that our thoughts and affections ought to soar above all the sinful pursuits, and transitory enjoyments, of this sublunary scene.

Such being the views and the tendencies of this science, it ought to be considered as bearing an intimate relation to religion, and worthy

the study of every enlightened Christian. It has been said, and justly, by a celebrated poet, that "an undevout astronomer is mad." The evidence of a self-existent and eternal Being, whose wisdom is inscrutable, and whose power is uncontrollable, is so palpably manifested in the arrangement and the motions of the celestial orbs, that it cannot but make an indelible impression on every rational and reflecting mind. Though the heavenly bodies have "no speech nor language," though they move round the earth in silent grandeur, and "their voice is not heard" in articulate sounds, yet "their line is gone throughout all the earth, and their words to the end of the world"—proclaiming to every attentive spectator, that "the hand that made them is divine." So that there is scarcely a tribe or nation on the face of the earth so inattentive and barbarous as not to have deduced this conclusion from a survey of the movements of the celestial orbs. "Men," says Plato, "began to acknowledge a Deity, when they saw the stars maintain so great a harmony, and the days and nights throughout all the year, both in summer and winter, to observe their stated risings and settings." Another heathen philosopher, Cicero, thus expresses his sentiments on this point: "What can be so plain and clear as, when we be-

hold the heavens, and view the celestial bodies, that we should conclude there is some Deity of a most excellent mind by whom these things are governed—a present and Almighty God? Which, he that doubts of, I do not understand why he should not as well doubt whether there be a sun that shines, and enlightens the world."

The sacred Scriptures, in numerous instances, direct our attention to this subject. "The heavens," says the Psalmist, "declare the glory of God;" that is, they manifest his wisdom, and power, and beneficence to the inhabitants of the world; "the firmament showeth forth," or publicly declareth, "his handy-work." "Day unto day uttereth speech, and night unto night showeth knowledge. There is no speech nor language where their voice is not heard." In reference to that department of creation which astronomy explores, it may be said with peculiar propriety, in the language of Scripture, "The works of the Lord are great, sought out of all them that have pleasure therein." Throughout the volume of inspiration, our attention is frequently directed to the contemplation of the heavens: "Lift up thine eyes on high, and behold who hath created these things?—The everlasting God, the Lord, the Creator of the ends of the earth, who fainteth not, neither is weary; there

is no searching of his understanding.—He bringeth out their host by number, and calleth them all by names: by the greatness of his might, for that he is strong in power; not one faileth. —It is he that sitteth upon the circle of the earth, and the inhabitants thereof are as grasshoppers. —All nations before him are as nothing; and they are counted to him less than nothing, and vanity."—"Hearken unto this, O Job: stand still, and consider the wondrous works of God."

Hence it appears, that it is not to be considered merely as a matter of taste, or as a rational amusement, but as an imperative duty, to contemplate the works of the Most High, and especially the manifestation of his power and Godhead which the heavens display; that we may derive more enlarged conceptions of his glorious attributes, and be enabled to render to him that tribute of adoration and praise which is due to his name. For it is represented as one of the characteristics of the ungodly that, while "the harp, and the viol, and the tabret, and pipe, and wine are in their feasts,—they regard not the work of the Lord, neither consider the operation of his hands;" and consequently, "he will destroy them, and not build them up." It is therefore the incumbent duty of the young; of every professing Christian; and of every

rational inquirer, not only to study the facts, doctrines, and duties exhibited in the system of divine revelation, but also to contemplate the manifestations of the Creator as exhibited in the system of creation. They are both revelations of the same almighty and beneficent Being—emanations from the same adorable Divinity; and the views and instructions they respectively unfold, when studied with reverence and intelligence, are in perfect harmony with each other. The study of both combined is calculated to make the man of God perfect, and "throughly furnished unto all good works."

In the following small volume it shall be our endeavor, after a brief sketch of the history of astronomy, to direct the general reader in the study of some of those objects which the heavens unfold; and we shall chiefly select those parts of astronomical science which are most level to the comprehension of those who have had little opportunity of engaging in scientific pursuits. In the present volume it is proposed to confine ourselves chiefly to a description of the Solar System, and the phenomena it exhibits, together with a few instructions as to the best mode of contemplating the apparent motions and the diversified aspects of the firmament. The discoveries which relate to the sidereal heavens;

the general arrangement of the fixed stars, their distances and magnitudes; the facts which have been discovered respecting new stars; variable stars; double and triple stars; the milky way; the different orders of the nebulæ; and a variety of other topics connected with such subjects, will form materials for another volume similar to the present.

In the mean time we may just remark, that all the wonders we behold, both in the heavens above and in the earth beneath, demand our serious attention and devout contemplation. They are all the workmanship of that great and adorable Being in whom "we live and move;" who at first "spake, and it was done;" who gave the command, and the whole of this stately fabric of heaven and earth started into being. It is the same God who created the planets and the host of stars, and that conducts them in all their rapid motions; who is also "the God and Father of our Lord Jesus Christ," and "the Author of eternal salvation" to all who obey him. All these works display his infinite power, his unerring wisdom, and the riches of his beneficence; and demand from every beholder that tribute of praise, reverence, and adoration, which is due to Him "who created all things, and for whose pleasure they are and were created."

BRIEF SKETCH OF THE HISTORY OF ASTRONOMY.

ASTRONOMY was undoubtedly one of the earliest of the sciences cultivated by the human race. Some of its facts and first principles must have been known from the beginning of the world. For when the shades of night opened to view the azure firmament, diversified with a multitude of shining orbs—the moon walking in brightness—the planets moving in their courses—and the host of stars displaying their diversified radiance—such a scene must have attracted the attention of every spectator, and led him to observe their apparent motions, and to inquire into their order and arrangement, and their use in measuring the exact length and proportion of days, and months, and years. Hence Milton very properly represents our first progenitors, Adam and Eve, celebrating the praises of their Maker, after taking a survey of the nocturnal heavens.

Adam. "These are thy glorious works, Parent of good,
Almighty! thine this universal frame.
Thus wond'rous fair; thyself how wond'rous
then!

Eve. Unspeakable! who sitt'st above these heavens
To us invisible, or dimly seen

In these thy lowest works; yet these declare
Thy goodness beyond thought, and power divine," &c.

Josephus, in his book of the "Antiquities of the Jews," relates that "Seth and his descendants were persons of happy tempers, and lived in peace, employing themselves in the study of astronomy, and in other researches after useful knowledge." He also remarks that "God indulged the antediluvians with a long life, that they might bring astronomy and geometry to perfection." And the long lives of men, at that period, when many reached the age of eight or nine hundred years, had a tendency to improve the science of astronomy; since the same individual might observe the planet Saturn go through more than thirty revolutions. We have, therefore, reason to conclude that many of the antediluvians were intelligent astronomers: but their observations, if they were ever recorded, must have perished in the general deluge, unless Noah, who was a wise and good man, had secured some of the most valuable of them in the ark, and transmitted the results to his posterity.

After the deluge, the nations most noted for the cultivation of the science of the heavens were the Chaldeans, the Egyptians, and the

Chinese. It is remarked by Josephus that Abraham was a most attentive observer of the stars; that he was a person of great sagacity, both for understanding all things, and persuading his hearers, and that he first brought astronomy from Chaldea into Egypt.

The Egyptians appear to have made some progress in astronomy at as early a period as the Chaldeans. Their pyramids, the most ancient monuments in the world, prove their skill in practical astronomy, as they are all situated in such a manner that their several sides front very exactly the four cardinal points, east, west, north, and south. The system adopted by the Egyptians was the following: they conceived that the planets Mercury and Venus revolved like satellites around the sun, their orbits being carried along with him in his revolution round the earth. They supposed the earth immovable as the centre of the system, and the other celestial bodies to turn round the same centre; first the moon, then the sun, about which they supposed Mercury and Venus to revolve, next the planet Mars, then Jupiter, next to Jupiter, Saturn, and lastly the sphere of the fixed stars. The Chinese pretend that their nation studied astronomy soon after the flood, and date their astronomical knowledge from Fohi, the first of

their kings; supposed by some to have been Noah, as it is understood that he journeyed with his children in the direction of China, about the time of the building of the tower of Babel.

Among the Greeks, astronomy was cultivated by Thales, the Milesian, Anaxagoras, Anaximander, Pythagoras, Aristarchus, and others. Pythagoras, who flourished about five hundred years before the Christian era, taught that the sun is in the centre of the universe; that the earth is globular, and moves round the sun; that Venus is the morning, as well as the evening star; that the moon reflects the sun's rays, and is inhabited; that the stars are worlds, and that comets are wandering stars. This is nearly the system which was restored by Copernicus, in the fifteenth century.

Hipparchus, born at Nice, in Bithynia, appears to have made considerable advances in the cultivation of every branch of astronomy. He flourished about one hundred and forty years before Christ. He was among the first astronomers on record who attempted to number the stars, and to determine their exact positions. He was first induced to commence this labor in consequence of the appearance of a new star, in order that succeeding astronomers might learn whether any changes take place in the heavens.

Ptolemy, a native of Pelusium, in Egypt, born in the year 69, is the most ancient astronomer whose works have been handed down to our times. His Almagest, or the great composition, is that to which we are indebted, not only for its own observations, but for almost all that remains of Hipparchus, Aristillus, Timocharis, and the ancient Babylonians. According to the system of Ptolemy, the earth is immovable in the centre of the universe, and the planets move around it in the following order: first the moon, then Mercury and Venus; next to Venus the sun; then Mars, Jupiter, and Saturn, in the order here stated; and above all these, the firmament of the fixed stars, all which were conceived as revolving around the earth every twenty-four hours. He supposed that the planets moved round the earth, each in a vast solid transparent globe, having the planet attached to its surface; and as these transparent spheres did not account for all the motions and apparent irregularities of the heavenly bodies, he contrived other and still more complicated machinery, such as cycles, epicycles, deferents, &c., in order, if possible, to solve appearances. This system, notwithstanding its absurdity, and its contrariety to the appearances of the universe, continued in vogue, even among the learn-

ed, for the space of more than one thousand four hundred years, or till the middle of the fifteenth century. During this period, a few individuals appeared who cultivated astronomy, such as Almansor, Almanon, and others among the Arabians; Ulugh Beigh, a prince of Tartary; Alhazen, an Arab in Spain; Alphonso X., king of Castile; Roger Bacon, and several others; but they all adopted the absurd hypothesis of Ptolemy.

About the beginning of the sixteenth century, Copernicus, a bold and original genius, began to be distinguished for his attainments in astronomy. Perceiving that the clumsy and unnatural system of Ptolemy could never account for the motions and appearances of the celestial orbs, he adopted the Pythagorean system, which had been broached five hundred years before Christ, and wrote a profound treatise in confirmation of it, entitled, "Astronomy Restored; or, The Revolutions of the Celestial Orbs." With a bold and daring hand, he dashed the crystalline orbs of Ptolemy into pieces, swept away his cycles, epicycles, and deferents, placed the sun in the centre of the system, removed the earth from its quiescent state, and set it in motion through the regions of the firmament, in company with the other planetary orbs. This

system was at first violently opposed by the vulgar, the dignitaries of the Romish Church, and pretended philosophers, as contrary both to sense, reason, and Scripture, and many of its abettors were subjected to violent persecutions. But it is now universally received by all men of learning, and by every one who has investigated the motions and other phenomena of the heavens. It has opened to our view the harmony and order of the planetary system, the wisdom and intelligence of its great Author, and laid the foundation of all the discoveries which have subsequently been made in this science. It was afterward ably supported by the writings and observations of Galileo, Kepler, Gassendi, Hevelius, Huygens, Cassini, and other celebrated astronomers, by whom its principles have been established on a foundation stable and permanent as the laws of the universe.

About sixty or seventy years after the publication of this system, the invention of the telescope, and the discoveries made with this instrument by Galileo, tended to confirm its principles, and to expand our views of the sublimity, the variety, and multitude of the objects which the universe displays. This illustrious astronomer first discovered, by his

telescope, the satellites of Jupiter, the phases of Venus, the spots of the sun, and the rotation of this globe round its axis, the mountains and vales in the moon, the stars in the Milky Way, and an extraordinary phenomenon, which he imagined to be two small globes, connected with the planet Saturn. These discoveries were made about the year 1610, soon after the telescope was invented. About forty-eight years afterward, Huygens, a celebrated mathematician and astronomer, in Holland, with telescopes of a much larger size than those of Galileo, discovered that the phenomenon connected with Saturn was, in reality, an immense ring surrounding that planet, and thirty thousand miles distant from every part of it. He, at the same time, discovered the fourth satellite of Saturn; and in these and other observations he used telescopes of his own construction of twelve, twenty-three, and even one hundred and twenty feet in length. Some time afterward, Cassini, a French astronomer, discovered the first, second, third, and fifth satellites of Saturn, and the periods of the rotation of Mars and Venus.

About the period to which we now allude, flourished the illustrious Sir Isaac Newton, who laid the foundation of physical astronomy. About the year 1666, when in the twenty-fourth year

of his age, he retired from Cambridge into the country on account of the plague, and sitting one day in an orchard, under a tree, an apple happening to fall upon his head, led him into a number of reflections. Reflecting on the power by which all terrestrial bodies gravitate toward the earth, it occurred to him, that as this power is not sensibly diminished in any distance to which we can recede from the earth's centre, there seemed reason to conclude that it extended much further than it was generally supposed, and even might extend as far as the moon; and if this were true, he concluded that her motion would be influenced by it, and that probably it was this very force which retained her in her orbit. Following out these sublime conceptions, he began the composition of his immortal work, the "Principia," which was published in 1687, in Latin, under the title of "Mathematical Principles of Natural Philosophy." He also invented a reflecting telescope, which bears his name.

Contemporary with Newton were Dr. Hooke, Flamstead, Halley, Bradley, Roemer, Richer, Picard, Muraldi, and others, whose labors greatly contributed to the improvement of astronomy. Flamstead was the first astronomer royal in the Observatory at Greenwich, and, for

nearly half a century, was assiduous in his observations of the heavenly bodies. He formed a catalogue of more than three thousand stars, with their right ascensions, longitudes, polar distances, and apparent magnitudes. Roemer, a Danish astronomer, was the first who discovered the progressive motion of light. By comparing the eclipses of the first satellite of Jupiter with the times of their immersions and emersions, given by the tables of Cassini, he found that the error of the tables depended on the distance between Jupiter and the earth, and hence he concluded that the motion of light was not instantaneous, and that it moved across the diameter of the earth's orbit in about sixteen minutes, or at the rate of 192,000 miles in a second.

Few discoveries were made in the heavens from the beginning of the eighteenth century till the period when Sir W. Herschel applied his large telescopes to the spaces of the firmament. His discoveries have greatly extended our views both of the planetary system, and of the sidereal heavens. On the 13th of March, 1781, he discovered a new planet beyond the orbit of Saturn, to which he gave the name of Georgium Sidus; but it is now generally distinguished by the name of Uranus. On the

11th January, 1787, he discovered the second and fourth satellites which moved round this planet; in 1790 and 1794, he discovered four other satellites revolving round the same body. In 1789 he discovered the sixth and seventh satellites of Saturn; he also determined the rotation and figure of this planet—discovered that it had a double ring, and was marked with several belts parallel to its equator. His son, Sir J. Herschel, has also distinguished himself by his unwearied observations on the heavens. In conjunction with Sir J. South, he produced a catalogue of 380 double stars, whose distances and angles of position they had determined with the utmost precision. Sir J. Herschel afterward produced a list of upward of 3,300 double and triple stars, from his own solitary observations, accompanied with all the micrometrical measurements; and, about ten or twelve years ago, he went to the Cape of Good Hope for the purpose of making observations in the southern region of the heavens, and made some interesting discoveries. On the 1st of January, 1801, M. Piazzi, a Sicilian astronomer, discovered a small planet between the orbits of Mars and Jupiter, which has been named Ceres. On the 28th March, 1802, Dr. Olbers, of Bremen, discovered another planet, near the same region,

which is named Pallas. On the 1st September, 1804, Mr. Harding, of Lilienthal, discovered another, which is named Juno, distinguished for the great eccentricity and inclination of its orbit. On the 26th March, 1807, Dr. Olbers discovered a fourth planet, which he named Vesta. The latest discovery of this kind we have to record was made by Mr. Hencke, of Driessen, on the 8th December, 1845, when he discovered another planet somewhat similar to the four now mentioned, which is nearly at the same distance from the sun, and accomplishes its revolution in nearly the same period as the others. This planet has been named Astræa.

In the present day there are many distinguished cultivators of astronomical science, from whose observations and researches new discoveries may be expected. The names of South, Herschel, Airy, Smyth, Robinson, the earl of Rosse, Schumacher, Struve, Harding, Bersel, Arago, and a multitude of others, are well known as distinguished cultivators of the science of the heavens. It is to be hoped that the earl of Rosse, by means of the large and splendid telescope he has lately erected, will be enabled to make new discoveries, and to enlarge our views of the grandeur of the sidereal heavens. He has already analyzed some of the nebulæ, and

shown them to consist of immense clusters of stars which could not be perceived by any former telescopes; and this, we would hope, is only a prelude to still more sublime discoveries. What further advances astronomy may yet make, we dare not venture to anticipate. The number of individuals who devote themselves to this study is gradually increasing; its instruments of observation are rapidly improving; and we can scarcely set boundaries to the discoveries that may yet be made. In future ages, man, by the improvements in optical and other instruments, may be able to penetrate much further into the distant regions of the universe than he has hitherto done, and may descry myriads of objects which have hitherto remained invisible in the unexplored regions of immensity. And after all the discoveries which mortals can bring to view from this terrestrial sphere, the greater part of the works of the Almighty will still remain to be explored throughout the ages of eternity.

CHAPTER I.

ON THE GENERAL ASPECT, AND THE APPARENT MOTIONS, OF THE HEAVENS.

PREVIOUS to entering on the study of astronomical science, and the phenomena of the solar system, it is requisite that the young inquirer should be directed to contemplate the general aspect of the heavens, and the apparent motions of the different bodies which present themselves to view in the regions of the firmament. No one can enter with intelligence on the study of astronomy, or acquire an accurate idea of its elementary principles, and of the arrangement and motions of the planetary bodies, unless he has been led to observe, with his own eyes, the apparent and more obvious phenomena and aspects of the celestial orbs, as they present themselves to the view of any common and attentive spectator. For although the real motions of the heavenly bodies are, in many instances, very different from their apparent movements, and although many of them appear to move while they are absolutely at rest, yet it is necessary that their apparent motions and appearances should be accurately inspected, in order that, in the progress of investigation, we

may be enabled to determine what bodies are really in motion, and what only appear to be in motion, in consequence of the motions of other bodies. In order to direct the untutored observer on this point, the following observations are stated.

Section I.—*On the Apparent Motions of the Heavens during the Day.*

In the first place, let us consider the appearance of the heavens as seen in the daytime. Sometimes it happens for days, and even for weeks together, that the sky is overcast with an assemblage of sable clouds covering the whole face of the firmament. In which case no celestial orb makes its appearance; but the light, transmitted through the clouds and reflected from their under services, indicates that some luminous orb, the fountain of light, is above our horizon, and far beyond the upper region of the clouds, though its form and splendor cannot be perceived. At other times the concave of the sky appears of an azure color, where scarcely a speck of cloud is to be seen; like a boundless desert, where no celestial orb makes its appearance; as at the dawn of the morning, when the aurora makes its appearance in the east. This faint light gradually increases,

rising higher and higher in its brightness, a prelude of something still more grand and refulgent. The clouds near the horizon are tinged with purple and vermilion, and the mountain tops are clothed with brightness. At length, the disk of the sun disengages itself from the horizon by degrees, till the whole of his orb appears to view, and ascends the heavens with majestic grandeur. The sun is the only object which, during the day, appears conspicuous to the naked eye; for although the moon is frequently visible in the daytime, yet she then appears with no greater brilliancy than a small cloud of the same size, and is scarcely noticed by a common observer.

The apparent movements of the SUN appear very different at different seasons of the year, and in different regions of the globe. In describing these apparent motions, we shall suppose ourselves, in the first instance, in the latitude of fifty-two degrees north, which is nearly the latitude of London and several other large towns in England. The sun's apparent motions in this latitude will be nearly the same as when he is viewed from Holland, Denmark, Scotland, Nova Scotia, Canada, and the northern states of America. Suppose we begin our observations in winter, about the 21st Decem-

ber, when the days in our northern hemisphere are shortest. In this case, turning our eyes to the south-east quarter of the sky, a little after eight o'clock in the morning, we shall see the sun rising nearly on the south-eastern point of the compass, and gradually ascending the celestial vault. In about four hours, he comes to the meridian, or due south, the highest point of his elevation at that season; after which he gradually descends toward the west, and sets in the south-western part of the heavens, about four in the afternoon, having described a comparatively small arc of a circle above the horizon. At this time, when he arrives at the meridian, or the highest point of his diurnal course, he is only about fourteen degrees above the horizon.* If, after this period, the point at which the sun rises be observed, it will be found a little to the

* The circumference of the heavens, as well as that of the earth, is divided by astronomers into three hundred and sixty parts, called degrees: consequently, the distance from the horizon to the zenith, or the point directly above our heads, is ninety degrees, or the one-fourth of the circumference of a circle. When, therefore, the sun is said to be elevated above the horizon fourteen degrees, it means, that he has risen to an altitude little more than one-sixth part of the distance from the horizon to the zenith. The apparent breadth of the sun or moon is very little more than half a degree.

northward, every day, from the point at which he rose before. On the 21st of March, the sun rises due east, about forty-five degrees to the north of the point at which he rose on the 21st of December. The time of his rising is exactly six in the morning; six hours afterward, he passes the meridian, at an elevation of thirty-eight degrees; and sets due west, at six o'clock in the evening. At this time, the day and the night are of an equal length; namely, twelve hours each.

If, again, we view the rising sun on the 21st of June, we shall find that he rises near the north-east, forty-five degrees further to the northward than on the 21st of March. At this period, the sun describes a large circuit around the heavens; rising fifteen minutes before four in the morning, and advancing to an elevation of more than sixty degrees at noon-day; after which he declines toward the west, and sets near the north-west quarter of the heavens, about a quarter past eight in the evening. The length of the day, at this time, is about sixteen and a half hours; and as his course during the night is not far below the horizon, there is no absolute darkness during the absence of the sun; and his course may be traced by observing the motion of the twilight, or the aurora, gradu-

ally proceeding to the northern point of the heavens, and from that point to the north-east, where the solar orb again emerges from the horizon. After this period, the sun begins, every succeeding day, to rise in points nearer the south, and to take less extensive circuits round the heavens, till the 23d of September, when he again rises on the eastern point of the horizon, and sets in the west, which is the time of the autumnal equinox, when day and night are equal. From this period the sun gradually verges to points of the horizon south of the east, at the time of his rising, and the days rapidly shorten, till he again arrives near the south-eastern quarter of the heavens, where he is seen to rise on the 21st of December. Such are some of the apparent motions of the sun, in our quarter of the globe, throughout the different seasons of the year; and every one who resides in the country has an opportunity, every clear day, of observing these diversified movements.

Besides the motions to which we have now adverted, there is another apparent motion of the sun, in a contrary direction, which is seldom noticed by a common observer. Every day the sun has an apparent motion from west to east, at the rate of nearly a degree each day; and in the course of a year, or 365 days, 5 hours, 48

minutes, and 51 seconds, he makes a complete circuit around the heavens. This motion manifests itself chiefly by the appearance of the heavens during the night. If, in the morning, some time before sunrise, we view those stars which are near the point of the horizon where the sun rises, in a week or two we shall find that the same stars are more elevated near the time of sun-rising than before, and further distant from him, indicating that he is moving through the heavens toward the east, and leaving these stars as it were behind him. If, again, in the evening, we mark those stars which are a little above the point of the setting sun, we shall find that every evening they make a nearer approach to the place where the sun goes down; till, after a short period, they approach so near this luminary, as to be overpowered with his rays, and can no longer be seen, still indicating that the sun is approaching toward the east.

Perhaps the best way of tracing this is to mark the different positions of the Pleiades, or seven stars, with respect to the sun. About the middle of January, at eight o'clock in the evening, the seven stars are seen nearly on the meridian, which observation should be noted down for the purpose of being compared with

future observations. On the 1st of March, at the same hour, these stars will be seen nearly half-way between the meridian and the western horizon, while all the other stars, at the same elevation, will be found to have made a similar progress. About the 15th of April, they will be seen, at the same hour, very near the north-western horizon; and every day after this, they will appear to make a nearer approach to that part of the heavens in which the sun appears, till, being overpowered by the splendor of his rays, they cease to be visible. From these and similar observations, it will be easily perceived that the sun has an apparent motion through the circle of the heavens, and that the revolution is completed in the course of a year. The circle which the sun thus describes is called the ECLIPTIC, and is divided into twelve signs, and three hundred and sixty degrees.

The apparent motions of the sun appear somewhat different, when viewed from different regions of the earth. Were we placed in countries under the equator, such as at Borneo, Sumatra, the Gallipago Isles, Quito, and other parts of South America, the sun at noon would shine directly from the zenith, at the time of the equinoxes, at which time objects would have no shadows. At all other times, the

sun will appear either in the northern or the southern quarter of the heavens. During the one-half of the year he shines from the north, and the shadows of objects fall to the south: during the other half, he shines from the south, and the shadows of objects are projected to the north; a circumstance which can never occur in our country, or in any part of the temperate zones. At the equator, too, there is a perpetual equality of days and nights throughout the year; the twilight is shortest, and the darkness of night rapidly succeeds the setting of the sun.

Were we placed in southern latitudes—for example, at the Cape of Good Hope, New South Wales, or Buenos Ayres, in South America—instead of beholding the sun moving along the southern part of the heavens, from the left hand to the right, as in our country, we should see him directing his course along the northern part of the sky, from the right hand to the left. In other respects, his apparent motions would nearly resemble those already described, excepting that when the sun is highest at mid-day to us, he appears lowest to the inhabitants of these countries; their winter happening at the time of our summer. Were we placed in Lapland, Greenland, or other countries within the polar circle, the sun in winter would be absent

for weeks, and even for months together; and in summer he would shine without intermission for a corresponding portion of time; appearing every day to make a complete circle round the heavens, but never descending below the horizon during the lapse of six weeks, or even three or four months. Could we suppose ourselves placed at the north pole, the motion of the sun would produce a different aspect from any of those now described. On the 21st of March, we should see a portion of the sun's disk appear in the horizon, after a long night of six months. This portion of the sun would appear to move quite round the horizon every twenty-four hours; it would gradually rise higher and higher till the whole orb of the sun made its appearance. As the season advanced, the sun would appear to rise higher and higher, till, on the 21st of June, he attained the altitude of twenty-three and a half degrees above the horizon; after which his altitude would gradually decline till the 23d of September, when he would again appear in the horizon. During the whole of this period of six months, there is perpetual day; the stars are never seen, and the sun appears to go quite round the heavens every twenty-four hours without setting, in circles nearly parallel with the horizon.

Such are some of the motions and aspects of the sun, as viewed at different seasons of the year, and from different parts of the earth. Let it be carefully remembered, that these motions are not real, but only apparent. While presenting all these diversified aspects and movements to spectators placed in different positions, it can be proved that the sun is, notwithstanding, a quiescent body in the centre of the planetary system. By the rotation of the earth round its axis from west to east every twenty-four hours, and by its revolution round the sun every year, all the apparent motions we have hitherto described are produced, and completely accounted for, as we shall afterward show, when we come to illustrate the evidences which prove that the earth on which we dwell is a moving body.

When we view the sun pursuing his course through the heavens in a clear and serene sky, we are apt to imagine that there are no other celestial bodies diffusing their rays above our horizon. This, however, is far from being the case. In the full blaze of day, there are as many stars, at an average, around us in the firmament, as are beheld in a clear sky at the hour of midnight; but their light is overpowered by the more brilliant splendor of the sun. By

means of equatorial telescopes, which can be made to point to any particular part of the heavens, all the larger stars of the firmament may be seen even at noonday, while the sun is shining in all his splendor; nay, there is scarcely a star visible to the naked eye, during night, but may be seen in this way during the blaze of day, and its exact position in the heavens pointed out. During a total eclipse of the sun, when the moon interposes her dark body between us and the sun, some of the planets and the larger stars have appeared as distinctly as at midnight; but the moment the moon has passed a little over the disk of the sun, and a glimpse of his beams has shone out, their feeble light becomes undistinguishable, and they are no longer perceived. Sometimes, too, it happens that stars have been seen from the bottom of deep wells and mines, when large ones happen to pass near the zenith during the day, and the planet Venus, when brightest, has frequently been seen with the naked eye in the daytime, when at no great distance from the sun. Thus it appears that the sun passes through the heavens every day with stars all around him, although invisible to the unassisted eye—just as the moon, during night, is seen surrounded with stars, which the faintness of

her light is not sufficient to overpower.* Hence it happens that astronomers can trace the exact path of the sun among the stars, every day, during his apparent annual circuit round the heavens. They can tell what stars are near and around the sun; what clusters he is leaving behind him, to what other clusters he is approaching; what stars or planets are near his margin, and what stars are behind his luminous globe, with as much accuracy as if they were all visible to the naked eye, as at midnight.

SECTION II.—*On the Apparent Motions of the Heavens during Night.*

When a careless observer, on a clear evening, gazes upon the firmament, he beholds a number of shining points, some of them far more brilliant than others, dispersed throughout every region of the sky; but he cannot tell whether they appear to move or to remain in a fixed position; whether they shift their positions with respect to each other; whether they

* The author has frequently seen, by the equatorial telescope, in the daytime, not only numerous stars of the first, second, and third magnitudes, in regions of the firmament at a distance from the sun, but has perceived the planet Venus, when immersed in the sun's effulgence, and when it was within a degree of the margin of that luminary.

rise and set; whether all the stars visible at six o'clock in the evening are also seen at midnight, or whether the same clusters are to be seen in summer as in winter. There are thousands and millions of mankind who have occasionally gazed on the starry vault who could give no reply to such interrogations. Such is the apathy with which the most wonderful works of God are viewed by the great bulk of mankind; although only a few days or hours of serious observation would be sufficient to solve some of the questions to which we allude.

In order to illustrate the apparent motions of the heavens, let us suppose ourselves placed in a situation which commands an extensive view of the sky, about the beginning of January, at eight o'clock in the evening. At this period, on a serene evening, when the sky is destitute of clouds, a sublime and beautiful spectacle presents itself to view, as some of the most brilliant constellations are then above the horizon. We behold a vast hemisphere expanding over our heads, whose centre we seem to occupy, and which appears to rest upon our horizon. Above and around us, on every hand, a multitude of brilliant orbs, of various degrees of splendor, display their radiance. But whether they are in motion, or at rest, does not appear

at the first glance. We must make different observations, and wait for some time till their motion, or rest, be discovered. To ascertain this point, let us fix on a particular star, or a cluster of stars, and bring it in contact with a church spire, a chimney top, the twig of a tree, or any elevated object, and our line of vision, and in a short time we shall find it has moved onward to the west, while we have remained stationary in our position. Or, if we direct a common telescope to any star, and fix the instrument in one position, in a few minutes the star will have passed from the field of view to the westward. If we look at a star near the horizon in the west, in a few minutes it will sink beyond the limits of our view, and disappear. If we mark any particular star just risen above the eastern horizon, in an hour or two it will be seen considerably elevated above its former position, and every minute rising higher and higher. If we look at any bright star rising due east, about six o'clock in the evening, at twelve, midnight, it will be on the meridian, or due south, at an elevation of thirty-eight degrees, and at six o'clock next morning it will be seen setting at the western point of the horizon. In like manner, any other star rising toward the east, north-east, or south-east, if carefully observed,

will be found to rise gradually till it come to the meridian, and then decline in a western direction, till it set either in the west, north-west, or south-west. If it rise in the north-east, it will set in the north-west, and if it rise in the south-east, it will set in the south-west; in the former case describing a larger, and in the latter a lesser portion of a circle, in the sphere of the heavens.

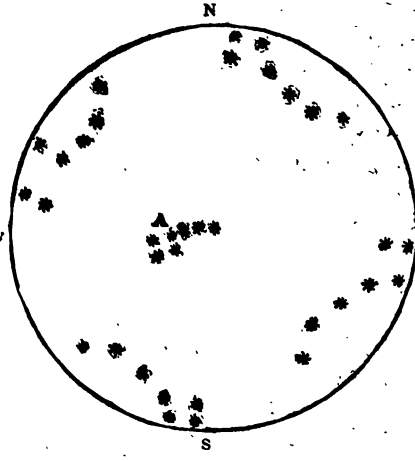
The following are some varieties which may be observed in the apparent motions of the stars. If you look toward the south you will observe some stars just appearing above the horizon, grazing this circle, as it were, but not rising above it, and then vanishing. If you observe a group a little to the east of the south, you will find them rising above the horizon, making a small arch, and then going down a little to the west of the meridian. If you mark another group rising much further to the east, you will find these describing a much larger arch, and taking a much longer time before they go down to the westward of the meridian. If now you turn your face to the northern part of the sky, you will find some stars that just skim the horizon, at certain times, near the north point, and then gradually mount up to the top of heaven, till they come nearly over head,

and then descend, and again nearly touch the northern horizon, and ascend again without ever disappearing, describing a complete circle above the horizon. Such are the bright stars Vega, Capella, and several others. Other stars that are higher than these, when seen near the northern horizon, likewise describe complete circles in the sky, without approaching the horizon; and these circles gradually diminish, till at last you arrive at a star which seems scarcely to move from the point where it is stationed—all the rest seeming to circulate round it as a centre. This is called the Pole Star, which, to a common observer, never seems to vary its position; and, in the latitude we have supposed, is elevated more than fifty degrees above the northern horizon. The time occupied by the stars now alluded to, in completing their circles, is about twenty-four hours, or, more accurately, in twenty-three hours, fifty-six minutes, and four seconds, and they all finish their revolutions in exactly the same period of time.

For illustration of what has been now stated, let us suppose ourselves to be viewing the northern quarters of the heavens, about the beginning of November, at eight o'clock in the evening. At this time, the Great Bear, or *Ursa Major*, will appear near the lowest part of

the horizon. I refer to this constellation, because it is generally known, even to common observers, and is sometimes distinguished by the names of "the Plough," and of "Charles's Wain." That part of the constellation which is generally recognized, consists of seven bright stars, of which the four toward the right form a kind of irregular square, and the three stars stretching out from it to the left form a kind of irregular curve. In the following figure (fig 1)

Fig. 1.



this constellation is represented in four positions.

Immediately above the letter S, in the lower part of the figure, are two stars, forming the right side of the square, the uppermost of which is called Dubbe, and the lower one Merak. They are about five degrees distant from each other, and are most frequently known by the name of "Pointers," because they always point toward the pole star. The pole star is represented in the central part of the figure; it is about twenty-nine degrees—or nearly six times the distance of the two pointers—from Dubbe, and in whatever position this constellation may happen to be, these two stars always point to the pole star, which is the first bright star in the line with pointers, at the proportional distance exhibited in the engraving; and by attending to this circumstance, the pole star may at all times be distinguished. Such is the position of this constellation at eight o'clock in the evening of the 1st of November. If now we view this constellation, about eleven o'clock the same evening, or a few evenings afterward, we shall find that it has moved considerably toward the east, and to a higher elevation; and at two o'clock the next morning, it will be seen in the position represented at E, with the pointers still directed to the pole star. At eight o'clock in the morning, it will be seen at N, when it will

appear in the zenith, with the pointers pointing downward toward the pole. At two o'clock in the afternoon, if it could then be seen, it would appear as represented at w, to the west of the pole, and the pointers pointing eastward to the polar star; and again, about eight in the evening it will return nearly to its former position at s.

Again, this constellation appears in different positions, at the same hour, at different seasons of the year. We have seen that, in the beginning of November, at eight o'clock in the evening, it appears as represented at s; in the beginning of February, at the same hour, it will appear as represented at E; in the beginning of May, as exhibited at N; and in the beginning of August, at the same hour, as represented at W.

In order that none of my readers may fall into mistakes, from what has been now stated, I may be permitted to mention the following anecdote:—A few years ago, I pointed out in the heavens, to a lady of my acquaintance, the constellation of the Great Bear, and showed her how she might mark its positions at different times, and its apparent revolution round the pole star. About a year afterward, she told me she had carefully made the observations to which

I had directed her, and found them to correspond to what I had stated. She appeared, however, to have paid no attention to any other stars but those of the Great Bear; and on putting several questions to her on the subject, I found that she conceived of the notion of the Great Bear as if it had been a huge monster pursuing its way through the midst of the surrounding stars, as if they had all been at rest, without apparently shifting their position—somewhat like a huge animal pursuing its way through a crowd, while every individual of the crowd remained nearly in the same position. Now, that my readers may not fall into the same mistake, let it be carefully remembered that all the stars in the neighborhood of the pole have the same apparent motions and revolutions as the Great Bear, all moving in concert, but some of them describing larger, and others smaller circles, around the polar point, and all completing their revolution in the same time, namely, in twenty-four hours.

Having represented the pole star in the centre of the engraving, to prevent mistakes, it may be proper to mention, that this star, although to a common observer it appears in a fixed position, is not exactly in the polar point: it is at present one degree and thirty-two minutes from the

north pole of the heavens, and revolves around it every day in a circle of about three degrees in diameter. This motion may be perceived by placing a telescope in a fixed position, and directing it to this star, when we shall find that, after an hour or two, it will have moved out of the field of view. There is no star exactly at the polar point, and this is called the polar star, because it is the nearest bright star to the north pole of the heavens. It forms the tip of the tail, or the extremity, of *Ursa Minor*, or the Lesser Bear, which likewise consists of seven stars, arranged very nearly in the shape of the Greater Bear, but in a reverse order. This constellation, which is much nearer the pole than *Ursa Major*, may be seen revolving around it, in the same manner as we have described above, but the stars of which it is composed are much smaller, and not so easily distinguished as those of *Ursa Major*. When the Great Bear is at its lowest position, as at a, (fig. 1,) the square of the Lesser Bear is considerably to the westward, and the four stars, of which it is composed, are directly above the tail of the Great Bear, at the distance of about twenty degrees, as at A.

Let us now suppose ourselves contemplating the southern, eastern, and western parts of the

heavens, about the beginning of January, at nine o'clock in the evening. At this time we shall see the seven stars, a very little to the west of the meridian, and at a very high elevation. Next to this cluster, on the east, but a little lower, is *Aldebaran*, or the Bull's Eye, a ruddy star of the first magnitude, in the constellation of Taurus. South by east of Aldebaran, and considerably below it, is the splendid constellation of Orion, distinguished by four bright stars forming an irregular square, or parallelogram, in the middle of which are three bright stars in a straight line, at equal distances from each other. This is one of the most splendid constellations in the heavens, and is distinguished by almost every common observer by the three stars now mentioned, which form the belt of Orion, or what Job calls "the bands of Orion," and are sometimes known by the names of "the three Kings," "the Yard," and "the Lady's Elwand." South-east from Orion, at a low elevation, is the star Sirius, belonging to *Canis Major*, or the Great Dog, which is considered the most brilliant fixed star in the heavens. North-east from Sirius, at a higher elevation, is Procyon, a bright star in *Canis Minor*, or the Little Dog. North from Procyon, at a much higher altitude, are the bright stars

Castor and Pollux, belonging to the constellation Gemini. If, then, three hours after having made these observations, or about midnight, we view the face of the heavens, we shall find a considerable alteration in the positions of the stars and constellations to which we have referred. The seven stars will then be found to have moved half way between the meridian and the western horizon, followed by Aldebaran, which is then a considerable distance past the meridian to the westward. The constellation Orion is likewise westward of the meridian, and the bright star Sirius, which was formerly in the south-east, is now nearly due south. Procyon, and Castor and Pollux, which, at nine o'clock, were a great way toward the east, are, at midnight, not far from the meridian, and at a much higher elevation. All which circumstances show that the various clusters of stars, in the eastern, southern, and western portions of the heavens, have a regular and uniform apparent motion from east to west.

Such are some of the general appearances of the heavens, as viewed in our northern latitude; but in several other quarters of the globe their aspects will appear somewhat different. Were we placed under the equator, in the island of Sumatra, or about Quito, in South America, we

should behold all the stars in the firmament proceeding in their courses from east to west. All the stars would appear to rise and set, and none of them would describe circles above the horizon, as some of them appear to do in our northern region. The north pole, which, in our latitude, is at a high elevation, would appear in the northern point of the horizon, and the south pole would, at the same time, be visible in the opposite quarter of the heavens. In our latitude, we cannot perceive above two-thirds of the stars which may be seen in the firmament, but, at the equator, all the visible stars of heaven may be perceived. During the space of twenty-four hours they all pass along above the horizon. The one half of them, indeed, cannot be seen on account of the light of day, but, in the course of a year, they are all visible. Were we placed in Van Diemen's Land, or at the Cape of Good Hope, we should behold multitudes of stars which are never visible in our latitude, and the constellations of the Great and Little Bears, Cassiopeia, and other clusters, would be no longer visible. Could we take our station at the north pole of the earth, the stars would appear neither to rise nor set, nor yet to stand still. All the stars visible from this point would appear to move round the heavens above the

horizon, in parallel circles, every twenty-four hours; and all that could ever be seen in such a situation might be perceived every hour and minute, in a clear sky, when the sun is absent. But, from this point, only one half of the firmament is visible, and none of the stars belonging to the other half ever rise above the horizon.

SECTION III.—*Conclusions deduced from the preceding Facts and Observations.*

An intelligent spectator, after having observed the various aspects of the heavens above described, will naturally inquire—Whence come those stars which are seen gradually emerging from the eastern horizon? Whither have those stars gone which have sunk beneath the western horizon? And what becomes of those stars during the light of day which shine with so much splendor during the shades of night? A little reflection on the subject will soon suggest, that the stars which are seen rising above the eastern horizon, come from another hemisphere of the heavens, which is invisible from the point on which we stand, and which we are apt to imagine is below the hemisphere which we behold above us; and when they set in the west, return to that hemisphere again; and that the reason why the stars are not visible during

the day is because their light is overpowered by the more vivid splendor of the sun. We are also naturally led to conclude, from such appearances, that the world in which we dwell is suspended in empty space, and is surrounded on all sides, above and below, by the expanse of the firmament, in which the sun, moon, planets and stars, appear to perform their diversified motions and revolutions. Another conclusion which may be deduced from the preceding observations is, that the whole sphere of the heavens performs an apparent revolution round our world; carrying, as it were, all the stars along with it in the space of twenty-four hours. Whether this motion be real, or only apparent, requires to be determined by certain rational considerations, and from the harmony and order which appear to be characteristic of the works of the Creator: to which subject we shall particularly direct our attention in the following chapter.

In the mean time we may remark, that such general views of the motions of the starry firmament as we have already taken have a tendency to expand the intellectual faculties, and to elevate the mind to the contemplation of some great invisible Power, by which such mighty movements are conducted. When we

behold the vast concave of the sky, with all its radiant orbs, moving in majestic grandeur around our globe, an idea of sublimity and almighty energy irresistibly forces itself upon the mind, which throws completely into the shade the mightiest efforts of human power—so that the most stupendous machines ever constructed by human art can afford no assistance in forming a conception of that incomprehensible Power which sustains and carries forward in their course thousands of spacious worlds. The shining orbs which the firmament displays are evidently placed at an immense distance from the earth, and consequently are bodies of an immense size; and if the apparent motions to which we have adverted were real, the swiftness with which they would fly through the regions of space would exceed all human calculation and conception. But whether these motions be real or apparent, we find motions actually existing among the orbs of heaven which astonish and overpower every rational and contemplative mind. The very circumstance, that motions so sublime appear in the expanse of the firmament, is a demonstrative proof that motions of a wonderful and incomprehensible nature exist somewhere; and the ideas of majesty, of grandeur, and of omnipotent energy,

which this single circumstance is calculated to inspire, are such as irresistibly to lead the mind to the contemplation of a Being whose perfections are incomprehensible, and whose "ways are past finding out."

It does not require a scientific knowledge of astronomy, in order that the mind may be impressed with sentiments of admiration at the movements which appear throughout the universe. For the works of God, when contemplated in any point of view, or on any theory or hypothesis we may form, appear, like himself, wonderful, magnificent, and incomprehensible. The motions to which we have chiefly alluded are either in the earth or in the heavens. If these motions really exist in the heavens, the mind is overpowered with astonishment at the idea of thousands and tens of thousands of vast globes of light, at immense distances, every day revolving around us with amazing velocity. If the motion chiefly exist in the earth, then we are still overwhelmed with wonder at the idea of a globe containing two hundred millions of square miles, with its mighty continents and oceans, and its numerous population, whirling round its axis every day, at the rate of a thousand miles an hour, and, in its course round the sun, flying with a velocity of eleven hundred

and thirty miles every minute! There is no alternative but that of admitting either the one or the other of these motions; and whatever view we take of this subject, or in whatever light we contemplate the phenomena of the heavens, we are almost irresistibly led to exclaim, "Great and marvelous are thy works, Lord God almighty!" "Who can utter the mighty operations of Jehovah!" "The Lord God omnipotent reigneth!" The idea of a Being who thus incessantly displays such amazing energies demands from all his intelligent offspring a tribute of reverence and adoration, of gratitude and praise.

Especially is it so when we consider that He who thus "rules universal nature" is the God of mercy and of grace. The power of the Almighty, as manifested in his works, is far excelled by its displays in connection with the mediatorial work of Jesus Christ our Lord. Here we behold it sustaining the Redeemer under "the travail of his soul," when he was made "an offering for sin;" raising him from the dead, and declaring him to be the Son of God; working mightily in the hearts of men by the instrumentality of his word, and the grace of his Spirit, that they may receive the truth in the love of it; and making those who believe

the gospel "meet to become partakers of the inheritance of the saints in light." May every one who peruses these pages experience this power!

CHAPTER II.

ON THE FIGURE AND MOTION OF THE EARTH.

SECTION I.—*On the Figure of the Earth, and the Arguments which prove that it is nearly in the Shape of a Globe.*

IN the preceding chapter we have given a description of the principal motions which appear in the heavens, both by day and by night. Every one, however illiterate, who has a desire to study "the wonderful works of God," has an opportunity, if he please, to observe most of the motions and phenomena to which we have adverted, provided he live in the country, or in a spacious street or square. Those who live in the narrow and dirty lanes and courts of cities have no scope for making such observations, unless they occasionally retire to the open fields; and hence it is that the inhabitants of such places seldom know anything of the general aspects either of the earth, or of the heavens. It is, however, the incumbent duty

of every man, and particularly of every Christian, to contemplate, with an eye of intelligence and devotion, the operations of the Most High, in order that he may be enabled to "praise Him for his mighty acts," and "according to his excellent greatness." And the man who will not give himself the trouble of occasionally devoting an hour or two to such studies and observations, virtually declares that the works of his Creator are unworthy of his contemplation; and, consequently, that he deserves to remain in ignorance of the most sublime objects of creation, and of the most glorious manifestations of the Divinity.

Before proceeding to a particular description of the planetary system, it is requisite that we should acquire clear and definite views of the figure and motions of the earth on which we reside; without which the general frame of the universe, and the order and arrangement of the solar system, cannot be appreciated or understood.

For a long period, during the dark ages, and the infancy of science, the world in which we dwell was considered as the largest body in the universe. It was supposed to be an immense plain, diversified with a few inequalities, caused by the mountains and vales; and that

it stretched out in every direction to an unlimited extent, and was bounded on all sides by the sky. What was below this immense mass of land and water, and how it was supported, none could tell; though some of the Christian fathers strenuously asserted that the earth was extended infinitely downward, and established upon several foundations. Such were the absurd and foolish opinions of those who viewed the system of nature through a false medium, and who were ignorant of the facts and principles of modern science. It is only within the period of the last three hundred years that the true figure and dimensions of the earth have been accurately ascertained. This figure is now found to be that of an oblate spheroid, very nearly approaching to the shape of a globe, or sphere. That this is in reality the form of our world will appear from the following considerations.

1. When, on a calm day, we take our station on the seashore, we shall perceive that the surface of the water is not quite plane, but a little convex, or rounded; and if we happen to be on one side of an arm of the sea, two or three miles broad, if we place our eyes near the water, and look toward the opposite coast, we shall plainly see the water elevated between our eyes and

the opposite coast, so as to prevent our seeing the objects which are near the edge of the water. If we make the same experiment on a lake of two or three miles in extent, a small boat near the end of the lake may be seen by a man who is at some height above the water; but if we lay our eye near the surface, the view of the boat will be intercepted by the convexity of the water, which shows that the lake is a small segment of a globe.

2. When we view a ship taking its departure from the coast in any direction, as it retires from our view we may perceive the masts and rigging of the vessel when the hull has disappeared, and has sunk, as it were, beyond the boundary of our sight. First we lose sight of the hull, then of the sails, and last of all of the topmast. On the other hand, when a ship is approaching the shore, the first part of it which is visible, when at a considerable distance, is the topmast; as it approaches nearer, the sails begin to be seen; and last of all the hull gradually comes within the limits of our sight—but the vessel will pass over several miles of the sea, from the time of our first perceiving the topmast till the hull appears. In order to make such observations with accuracy, it is requisite that a telescope should be

used. What is it, then, that prevents the hull of a ship from being perceived when its topmasts are visible? It is evidently the round, or convex surface of the water rising up, as it were, or interposing between our eye and the lower part of the ship, when it has receded a certain distance. Now, as such appearances are observed on every sea and ocean on the face of the earth, it follows that the ocean at large is a convex surface, or a portion of a globe; and if the ocean be globular, so also is the land—notwithstanding that the hills and mountains form a few inequalities on its surface—for the portions of the land are all nearly on a level with the ocean, with the exception of the ranges of elevated mountains.

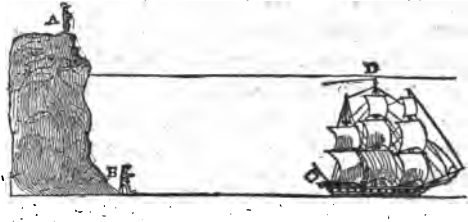
What has been now stated may be illustrated by the following figure, (fig. 2,) in which the convex surface of the globe is represented. At D a person is represented as standing on the top of a mountain; and from that elevation he is enabled to see both the topmast and the hull of the ship E; which is evident, because right lines can be drawn, without interruption from the eye, both to the topmast and to the hull. Whereas a line drawn from the eye to the hull of the ship F, which is at a greater distance, is intercepted by the convex surface of the water interposing,

Fig. 2.

and consequently the hull is invisible; but a line drawn from the eye to the higher parts of the vessel shows that the topmasts are visible, because light, when passing through the same medium, flows in straight lines from every object. In conformity with what has been now stated, we find that the higher the eye is placed, the further will the view be extended. From a lofty mountain we obtain a much more distant and extensive prospect than from the plain below; and hence it is common for sailors to ascend to the top of the ship's mast, when they wish to descry objects at the greatest distance; as from

such an elevation they can discover land, or other ships, at a greater distance than when they stand on deck. On the other hand, were the surface of the sea a level plain, as represented in fig. 3, the appearances would be very different.

Fig. 3.



A line might be drawn from any object situate upon it, as the ship D, to the eye, whether it were placed high or low, at A or at B. In this case, any object upon the earth or sea would be visible at any distance which was not so great as to make the appearance of it too faint or small to be perceived. An object would be visible at the same distance whether the eye were high or low. The largest, and not the highest, objects would be visible at the greatest distance. The topmast of a ship would first disappear, and the hull, as being the largest body, would be longest visible; but this is contrary to all experience. The considerations now adduced are,

therefore, clear and decisive proofs that the earth is not an extended plain, but a globular body; and it is astonishing that such a conclusion was not generally drawn till a few centuries before the present age.

3. That the earth is round, from east to west, appears from actual experiment; for many navigators, by sailing in a westerly direction, have gone quite round it from east to west. They have set sail from England, crossed the Atlantic, rounded Cape Horn, sailed along the Great Pacific Ocean to the northern coasts of New-Holland, crossed the Indian Sea, and passing the Cape of Good Hope, have again arrived, by traversing the Atlantic, to the port whence they set out. This experiment therefore shows that the earth is round from east to west; but it does not prove that it is also round from north to south; for it has never been actually circumnavigated in that direction, on account of the obstruction caused to navigation by the immense masses of ice within the polar regions. Had we therefore no other proof of the earth's rotundity than this, we might be apt to suppose it somewhat resembling the shape of a cylinder. But that the earth is in reality round, from north to south, appears from the following circumstances. When we travel a considerable dis-

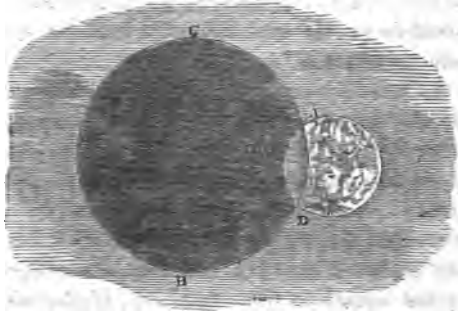
tancé from north to south, or from south to north, a number of new stars successively appear in the heavens in the quarter to which we are advancing, and many of those in the opposite quarter gradually disappear. For example, in sailing toward the south, when we approach the equator the brilliant constellation called the Cross makes its appearance, which is always invisible in this country; and if we go still further south, the constellations of the Great Bear, Cassiopeia, and other stars visible in our northern sky, will entirely disappear; which could not happen if the earth were a plain in that direction; for, in this case, all the stars of heaven would be visible in every point from the north pole to the south.

4. Another corroborative proof of the earth's globular figure is this: in cutting for a canal, in order to have the water on a level, certain allowances require to be made for the earth's rotundity. The slope requisite to be made on this account is about eight inches in the mile, thirty-two inches in two miles, and so on increasing as the square of the distance. If the earth were a plain, no allowances of this kind would be requisite, in order that the water in a long canal might stand on a level.

5. The phenomena exhibited in eclipses of

the moon present to the eye a clear demonstration that the earth is of a spherical form. It is well known that an eclipse of the moon is produced by the intervention of the body of the earth between the sun and the moon, which can only happen at the time of full moon, in which case the shadow of the earth falls upon the moon. This shadow is found in all cases, and in every position of the earth and moon, to be of a circular figure, or the segment of a circle, as the whole shadow cannot be seen at one time. Thus let A D (fig. 4) represent the moon

Fig. 4.



while an eclipse is going on, and C B the shadow of the earth, which is much larger than the diameter of the moon. In every stage of the progress of an eclipse, the curve A D of the

earth's shadow is distinctly perceived passing along the disk of the moon. But the entire shadow of the earth is not seen, because there is no bright object on which the whole of it can fall; only that part of it which covers the moon being visible. But since this shadow always appears a portion of a circle, it proves incontestably, that the whole mass of land and water of which the earth is composed is nearly of a globular form.

If, therefore, we admit that the earth is of a globular form, it necessarily follows that it may be inhabited on all sides, and consequently that those who live on the opposite side of the globe must have their feet pointing toward our feet, and their heads pointing in an opposite direction. Thus, in fig. 2, the person standing at A has his feet pointing to the feet of the one standing at B, and their heads pointing to regions of space directly opposite; and therefore if, by any motive power, they were to be carried forward in the direction to which their heads point, and the power to be continued, they would never meet through all eternity. The same may be said in reference to the persons supposed to be placed at C and D. It also follows, that could we suppose a hole bored through the centre of the earth, commencing at the point where we

[illegible] to the opposite side. [illegible] would [illegible] miles. [illegible] water is either [illegible] it [illegible] round [illegible] with immense velocity [illegible] Whichever of these circumstances we find it to be, a wonderful [illegible] is observed in the mind. [illegible] in simple space, we have presented to view a globe—containing [illegible] miles, and weighing at least [illegible] or more than two thousand billions of tons—resting upon nothing—suspended in the midst of infinite space, and surrounded by the immense bodies of the universe, with no material support but the invisible arm of Omnipotence, passing its immense mass of continents and oceans, and proceeding [illegible] into the depths of infinity. Or we suppose it to be turning round its axis, and revolving, at the same time, round the sun. Here we have presented to view a still more astonishing idea—a globe, of the large dimensions now stated, with its numerous population, flying through the spaces of immensity, without accelerating its speed a single moment, at the rate of nine hundred thousand miles every hour.

So that there is no view we can take of the works of the Almighty, in which we are not irresistibly excited to wonder and admire.

We may here also remark that the globular figure of the earth is evidently the best adapted to a habitable world. It is the most capacious of all forms, and contains the greatest quantity of area in the least possible space. It is the best adapted to motion, both annual and diurnal, every part of the surface being nearly at the same distance from the centre of gravity and motion. Without this figure, there could have been no comfortable and regular alternation of day and night in our world, as we now enjoy; and the light of the sun and the mass of waters could not have been equally distributed. Had the earth been of the figure of a cube, or pentagon, or of any other angular form, some parts would have been comparatively near the centre of gravity, and others hundreds or thousands of miles further from it. Certain countries would have been exposed to furious tempests, which would have overturned and destroyed every object; while others would have been stifled for want of currents and agitation of the air. One part would have been overwhelmed with water, and another entirely destitute of the liquid element; one part might have

enjoyed the benign influence of the sun, while another might have been within the shadow of elevations a hundred miles high, and in regions of insufferable cold. In short, while one country might have resembled a paradise, others would have been transformed into a chaos, where nothing was to be seen but barrenness and desolation. But the globular figure which the Creator has given to our world prevents all such inconveniences and evils, and secures to us all the advantages we enjoy from the equable distribution of light and gravity—of the waters of our seas and rivers, and of the winds and motions of the atmosphere. Hence it is that all the bodies of the planetary system are either spherical, or spheroidal bodies; nay, all the great bodies in the universe, so far as our knowledge extends, are found to be of a globular figure; and in this arrangement the wisdom and intelligence of the almighty Creator are clearly to be perceived.

In short, the discovery of the globular figure of the earth constitutes an important fact in the history of divine Providence, without which some of the grand designs of the Creator, in reference to our world, would not have been accomplished. It was in consequence of a knowledge of this fact that the continent of

America was discovered, and the blessings of civilization, science, and Christianity conveyed to that region of the earth. On a knowledge of the true figure of the earth the art of navigation depends: and in consequence of this, the greater part of the world has been explored, and the way prepared for carrying the tidings of salvation to men of all nations, through faith in the crucified Redeemer. On the knowledge of the true figure of the earth depends our knowledge of its magnitude and dimensions, and on our knowledge of its magnitude depends our knowledge of the distances of the sun and moon; and on our knowledge of the distance of the sun depends our knowledge of the respective distances of the planets, and the extent of the solar system; and on our knowledge of the extent of this system depend our conceptions of the distances of the fixed stars, and of the vast magnitude and extent of the material creation; and on our views of the immensity of the universe depend the enlarged conceptions we are now enabled to form of the attributes of that Almighty Being from whom we derived our existence, and whose "kingdom ruleth over all." Had the first link of this chain—our knowledge of the figure of the earth—been wanting, we should have remained in ignorance of all

the important consequences, now stated, which have resulted from this discovery—so intimately connected are all the branches of useful knowledge, both human and divine.

Had mankind always remained ignorant of this important fact, the circumnavigation of the globe would never have been attempted; vast portions of the habitable world would have remained unknown and unexplored; the intercourses which now subsist among the various tribes and nations of mankind could not have been carried on; the tribes of the greater portion of the heathen world, and the countries in which they reside, would have been unknown; no extensive missionary enterprises could have been carried forward; the knowledge of "the salvation of God" could not have been communicated to all the nations that dwell upon the face of the earth, according to the predictions of ancient prophecy; and our ideas of the majesty and grandeur of the great Creator and Redeemer of men would have remained as low and contracted as in the dark ages, when it was considered, even by ecclesiastics, as a heresy and a crime to maintain that the earth was round like a globe, or ball, and that it might be inhabited on all sides. But now, in consequence of the knowledge we have acquired on this

subject, the way is prepared for the accomplishment of the divine purposes and predictions in relation to our race; our knowledge of creation, and the perfections of its Author, is extended; the path to future improvement and discovery is laid open; and everything now appears, notwithstanding many obstacles, to be hastening onward to a glorious consummation.

SECTION II.—*On the Motions of the Earth.*

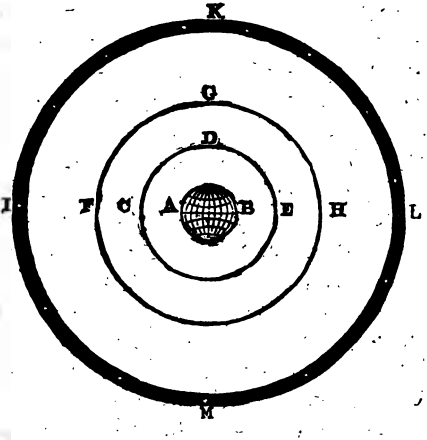
It is presumed that, in the times in which we live, there are few persons who have any doubts that the world in which we dwell is nearly of the figure of a globe, especially when this position can be proved by so many sensible demonstrations. But there are still many who can scarcely be convinced that it is moving along with immense velocity through the regions of space, in company with the other planets. On this subject, therefore, we shall now offer a few considerations, tending to prove that the world we inhabit—however steadfast it may appear to the eye of sense—is, in reality, a moving body, and that all its inhabitants are carried forward with a velocity far greater than any motions we see around us. There are two different motions considered as connected with the earth:—one, by which it is viewed as

turning round its axis every twenty-four hours; and another by which it wings its flight round the sun once every year. In the mean time, I shall chiefly illustrate those arguments by which its diurnal motion may be demonstrated.

1. In the first place, there is one thing of which we are all certain, that motion does actually exist, either in the earth or in the heavens. We every day behold the sun apparently moving from the eastern toward the western horizon. We find, likewise, all the stars in the firmament apparently moving in a body round the earth, in the course of twenty-four hours, and in the manner described in the preceding pages. Such observations, which every one has it in his power to make, clearly show that there is motion somewhere, and the question is—Does this apparent motion really exist in the heavens, or is it the motion of the earth that produces this appearance? Let us suppose, for a moment, that it is the earth which moves. What, then, will be the rate of its motion, in turning round its axis, to produce the apparent revolution of the heavens? For if the earth really move round its axis from west to east, the heavens will, of course, appear to revolve around us from east to west. The rate of this motion will

depend upon the magnitude of the earth. Now, we know that the earth is a globe, somewhat more than 24,000 miles in circumference; and, consequently, in turning round every twenty-four hours, some portions of its surface must move at least a thousand miles every hour. This is a motion far more rapid than has ever been produced in the smallest bodies by human art; and, therefore, it may appear incredible to some that such a motion can exist in a globe of such vast dimensions as the earth. But, if such persons deny that the earth thus moves, then they *must admit* that the heavens move. There is no alternative; for motion actually exists, either in the one or in the other. Now, if the motion is to be considered as existing in the heavens, let us consider what the rate of this motion must necessarily be. If a small globe, of eighteen inches diameter, were supposed to perform a revolution round its axis in two seconds, and a globe of 2,000 yards, or 72,000 inches in diameter, to finish a rotation in the same time, this larger globe would move with a velocity four thousand times greater than the other. In figure 5, if A B, in the centre, represent the earth, then, if the circle C E revolve round it in a certain time, and the other two circles revolve around it in the same time, it is

Fig. 5.



evident that the circle F H must revolve with a quicker motion than the circle C E, and the circle I L with a still greater velocity in proportion to its greater distance from the centre of motion, A B.

Let us consider, then, what would be the rate of motion of some of the bodies in the heavens, whose distance from the earth is known. The sun is ascertained to be ninety-five millions of miles distant from the earth, and, consequently, were he to move round the earth every day, as he appears to do, he would move along a cir-

cumference of 597 millions* of miles every day; that is, at the rate of above twenty-four millions of miles in an hour, 414,000 miles in a minute, 6,900 miles every second. Again, the planet Uranus, at its nearest distance from the earth, is more than 1,700 millions of miles distant; and consequently the circumference of its orbit is more than ten thousand six hundred millions of miles.

If, therefore, this planet were supposed to move round the earth every day, its motion would be at the rate of 445 millions of miles in an hour, seven millions four hundred and twenty thousand miles in a minute,—and one hundred and twenty-three thousand six hundred and seventy-seven miles every moment. Again, the nearest fixed stars are known not to be within 20,000,000,000,000, twenty billions of miles from the earth; and consequently their daily circuit round our globe would measure

* If the circle C D E represent the circle which the sun apparently describes in revolving round the earth, F C, its distance from the centre of the earth, represents 95,000,000 of miles, and the diameter of the circle C E 190,000,000; and as the proportion of the diameter of a circle to its circumference is nearly as 7 to 22, the circumference of the sun's circle, C D E, will be about 597,000,000 of miles, through which he behooved to travel every day, if the earth were at rest.

more than 125,000,000,000,000, one hundred and twenty-five billions of miles; that is, at the rate of fourteen hundred millions of miles in the space of a single second, or the interval of time which the pendulum of a common clock takes in moving from one side to the other! Stars, at distances a hundred times greater—of which there are many such in our firmament—would move with a rapidity a hundred times swifter; and those still further removed from us in the depths of immensity, with a velocity far exceeding either human or angelic comprehension. Yet all the stars of heaven appear to move round our globe every twenty-four hours. If the circle C D E (fig. 5) represent the supposed diurnal orbit of the sun; F G H that of Uranus; and I K L M that of some of the fixed stars; then it is evident, that in proportion to the distance of the body from the earth will be the velocity of its motion, if it be supposed to move round the earth every day.

If, therefore, there be any reader disposed to reject the motion of the earth, because it appears incomprehensible, he must necessarily admit of motions ten hundred thousand times greater, and far more incomprehensible,—more especially when we consider that the bodies in the heavens to which we have alluded are incom-

parably greater than this globe of earth on which we stand—the planet Uranus being more than eighty times, and the sun more than thirteen hundred thousand times, larger than the earth, and the fixed stars, at an average, as large as the sun. Such a rate of motion, in such a number of magnificent luminaries, appears altogether overwhelming, and, I may add, altogether incredible.

The question then which we have to decide is, which of the motions to which we have referred is most probable—the motions of the earth, or of the heavens? Is it really necessary that the whole universe, composed of sun, moon, planets, comets, stars, and nebulæ, should move round our globe with such astonishing velocities, in order to produce the alternate succession of day and night? Reason tells us that it is not. We know that the Almighty does nothing in vain, but employs the most simple means, in order to accomplish the most astonishing and important ends. The succession of day and night can be accomplished by a simple rotation of the earth on its axis, which will completely account for all the apparent diurnal revolutions of the celestial bodies. This we find to be actually the case with the other planets of the solar system. The planet Jupiter is fourteen

hundred times larger than the earth, and moves round its axis in less than ten hours, at the rate of 28,000 miles an hour, which is a velocity twenty-eight times greater than that of the earth, supposing it to move round its axis. The planet Saturn is nearly a thousand times larger than our globe, and it revolves round its axis in ten hours and a half, at the rate of 24,000 miles an hour, in those places situate near its equator. To a spectator placed on these planets, the heavens would appear to revolve around him every ten hours, as they appear to us to revolve every twenty-four hours, but with an apparently more rapid motion; while he himself might suppose, as we are apt to do, that he is actually at rest. The earth, therefore, must be considered as revolving round its axis, in accordance with the arrangements of the other planets of the system to which it belongs; and to suppose otherwise, would be in opposition to all the laws which govern the material universe, and would distort all our ideas of the harmony and order of the works of the Creator.

2. Another consideration which demonstrates the diurnal motion of the earth is this: that such a rate of motion in the heavenly bodies, as has now been stated, though it might be within the limits of divine power to effect, *would*

soon shatter the material universe to atoms, and reduce creation to a chaos. Were a ball of soft wood to be projected from a cannon, at the rate of eight hundred miles per hour, in a few moments it would be reduced to splinters; and hence the forage and other light substances projected from a piece of ordnance are instantly torn to pieces. What, then, might be supposed to be the consequences, were a body impelled through the ethereal regions with the velocity of a hundred thousand millions of miles in a minute, as multitudes of the stars behooved to be, were the earth at rest in the centre of the universe? It would undoubtedly reduce to atoms the most compact bodies in creation, although they were composed of substances harder than adamant.

3. Another corroborative argument in support of the motion of the earth is this, that *there is no instance known in the universe of a larger body revolving around a smaller*. We do not find such planets as Jupiter and Saturn revolving around their satellites, or moons; but all those satellites, which are much smaller than these planets, perform their revolutions around them, as the centre of their motions. The earth, which is fifty times greater than the moon, does not revolve around her, but that nocturnal luminary

regularly revolves around the earth. The sun does not revolve round the planets, Mercury and Venus—which are thousands of times less than that luminary—but they invariably revolve around him as the centre of light and influence. As the sun is one million three hundred thousand times larger than the earth, it cannot, therefore, be supposed for a moment, that such an enormous globe should revolve, with such an inconceivably rapid motion, around so inconsiderable a ball as the earth; and much less that the whole universe should revolve around it every day. Were the earth not revolving round its axis every day, there would be an infraction of all the laws which govern the system of universal nature; and therefore it is absolutely necessary to admit its motion, in order to direct our views, and to produce conviction of the unity of design, and of the harmony of creation.

4. The last argument I shall mention in the mean time, and which I consider as demonstrative on this subject, is this—that if the earth were at rest, and all the heavenly bodies revolving around it with dreadfully rapid motions, *it would confound all our ideas of the wisdom and intelligence of the Deity*. Wisdom is that perfection of an intelligent agent which enables

him to proportionate one thing to another, and to devise the most appropriate means to accomplish important ends. We should reckon that person foolish in the extreme who should construct, at an enormous expense, a huge piece of machinery for carrying round a grate, and the body of a large building to which it is attached, for the purpose of roasting a small fowl, fixed in the centre of its motions; instead of making the fowl turn round its different sides to the fire. Were the inhabitants of London, or any large town, to attempt to construct machinery to make the whole city move round in a circle, carrying a lamp near the centre to throw light and heat over a ball of only one inch in diameter, when the same purpose could have been easily effected by making the ball itself turn round its axis; we should not hesitate a moment in pronouncing such a scheme as a display of consummate folly. But none of these schemes would be half so preposterous as to suppose the vast universe to move round so inconsiderable a globe as the earth, to produce the alternate succession of day and night, when the same object can be effected by the earth's simply revolving around its axis. Such a device, therefore, cannot form any part of the arrangements of Infinite Wisdom. Can we sup-

pose for a moment, that what would be considered as the consummation of folly in mankind, is characteristic of the plans and operations of the Divinity, or that the great Source of eternal wisdom is to be leveled below the most foolish of men? Such a thought never can be admitted by any of his intelligent offspring, in relation to Him who is designated "THE ONLY WISE GOD," who "is wonderful in counsel, and excellent in working," and "who hath established the world by his wisdom, and stretched out the heaven by his understanding." If it could be proved that the earth is at rest, and the whole universe in motion around it, I should scarcely admit that the world was framed by that all-wise Being whose character is delineated in the sacred Scriptures, whose wisdom as far transcends that of man as the heavens are high above the earth.

I have been somewhat particular in exhibiting the arguments which prove that the earth is a moving body, because, in some minds, there is a great hesitation in admitting this fact, and in others, a disposition to receive it merely on the testimony of other men, without understanding the foundation on which it rests; and because right views and conceptions of such facts lead to right conceptions of the operations and

the attributes of that almighty Being whom we profess to adore. I shall take an opportunity of stating the arguments which prove the annual motion of the globe round the sun, when we come to describe the earth considered as a planet.

SECTION III.—*Reflections suggested by the Motions of the Earth and Heavens.*

We have now endeavored to prove to the intelligent reader, that the world in which we dwell, with all its continents, islands, oceans, and its numerous population, is continually revolving around its axis to bring about the returns of day and night. It is also flying with a still greater velocity around the sun, to produce the various changes of the seasons. What an august and sublime idea does this suggest for our contemplation! While we are apt to imagine we are sitting in absolute rest in our apartments, we are in reality whirling round toward the east at the rate of hundreds of miles an hour; and are, at the same time, carried through the regions of space with a velocity of sixty-eight thousand miles every hour; so that during every moment, or every pulse that beats within us, we are carried nearly twenty miles from that portion of space we occupied before. When we

lie down to sleep in the evening, we are seldom aware that, during our seven hours' repose, we have been carried along through the space of four hundred and seventy thousand miles! When, amidst the gloom of winter, we look forward to the cheering scenes of spring, we must be carried forward more than a hundred millions of miles, before we can enjoy the pleasures of that season; and when spring arrives, we must be carried, through the voids of space, hundreds of millions more, before we can enjoy the fruits of harvest! During every breath we draw, and every word we speak, we are carried forward in our course thirty, forty, or fifty miles, unconscious of the rapidity of our flight; but the motion is not the less real because we do not feel it. What should we think if one of the largest mountains in Scotland were to be seen flying through the atmosphere, across the island of Great Britain, with a velocity which would carry it from John-o'-Groats to the Land's End, a distance of seven hundred miles, in seven minutes? It would, doubtless, excite universal wonder and astonishment. But this is not one-tenth part of the velocity with which the great globe of the earth, with all that it contains, flies through the boundless regions of space. Were we placed on a fixed point,

a thousand miles distant from the earth, and behold this mighty globe, with all its magnificent scenery and population, thus winging its flight around the sun, and carrying the moon along with it in its rapid career, such a spectacle would overwhelm us with astonishment inexpressible, and even with emotions of terror, and would present to view a scene of sublimity and grandeur beyond the reach of our present conceptions. To angels, and other superior intelligences, when winging their flight from heaven to earth, and through distant worlds, such august scenes may be frequently presented.

Although the heavens do not in reality move round the earth, as they appear to do, yet there are thousands of globes in the celestial regions whose real motions are more swift and astonishing than even those to which we have now referred. The planet Venus moves in its orbit with a velocity of eighty thousand miles an hour; Mercury at the rate of one hundred and nine thousand miles an hour; and the planet Jupiter, which is one thousand four hundred times larger than the earth, at the rate of nearly thirty thousand miles an hour, carrying along with it, in its course, four globes, each larger than our moon. Some of the comets have been found to move more than eight hundred

thousand miles in the space of an hour; and some of the fixed stars, though apparently at rest, are moving with a velocity of many thousands of miles an hour. In short, we have every reason to believe that there is not a globe in the universe, nor a portion of matter throughout creation, but is in rapid and perpetual motion through the spaces of infinity, supported by the arm of Omnipotence, and fulfilling the designs for which it was created.

If we inquire into the original cause of these motions, we shall find that no other cause can be assigned but the fiat and the power of that omnipotent Being who at first said, "Let the universe appear," and it started into being. As matter did not make itself, so neither can it move itself; its motion must commence, and can only be continued every moment by the power of that almighty Being who brought it into existence. He alone who existed from eternity, whose power is uncontrollable, and whose wisdom is unsearchable, is the original Source of all motion, as he is the Source of all life and animation. By his omnipotent arm the planets were at first launched into existence, and impelled in their swift career, and the motion at first communicated, is every moment continued by the incessant agency of the same

almighty Power. Were that Power to withdraw its energy, or the subordinate means by which it is appointed to be continued, the universe would soon run into confusion, and creation be transformed into a chaos. But God, who "stretched out the heavens, and laid the foundations of the earth," hath appointed them a decree which they cannot pass, and they continue to this day, according to his ordinances, for all are his servants. Psa. cxix, 91.

What a scene of wonders is presented to view when we contemplate the motions incessantly going forward throughout the creation!—that thousands of globes, much larger than our world, are winging their flight with unremitting speed through the regions of immensity, at a rate which overwhelms the human imagination! What an astonishing idea does this convey of the energies of the eternal Divinity, who at first launched this earth and all the planetary globes from his powerful hand! He only "spake, and it was done;" and for thousands of years such motions have been continued without intermission! Well may we exclaim, with the inspired writers, "Who can by searching find out God?"—"Who can utter the mighty acts of the Lord? who can show forth all his praise?"

There are certain practical instructions which

may be deduced from this subject. The power of God, as displayed in the motions of the earth and heavens, teaches us that nothing can be too hard for Jehovah, and that all the declarations of his word, however wonderful and inexplicable to mortals, shall, in due time, receive their full accomplishment. We are assured, by the declaration of the sacred oracles, that a period is approaching when all the millions of the human race, whose bodies are now putrefying in the grave, and all the succeeding generations of men till the close of time, shall be reanimated from the tomb, and arrayed in more glorious forms than they now wear. We are also assured that this globe, on which we now reside, is destined to undergo an important and universal change, when its elementary parts "shall melt with fervent heat," and "the earth also, and the works that are therein, shall be burned up," as to their present constitution and aspect, and that a new arrangement will take place, in reference to the habitation to be allotted to the righteous. We perceive no symptoms of such changes at present; we have never seen any of the dead rise to life, after their bodies had mingled with the dust, and the ashes of some of them been scattered by the winds over different regions of the sea and land; and therefore

doubts are apt to arise in the mind, whether such wonderful transformations are possible to be effected. But all such doubts are at once dispelled, when we consider the perfections of Jehovah as displayed in the structure, and particularly in the movements of the universe, which afford us a sensible demonstration, that nothing, however inexplicable to us, can be beyond the range of Omnipotence. Therefore, we may rest assured that, when the time appointed in the decree of Heaven arrives, that power which carries the earth and all the celestial orbs in their rapid motions through the sky, shall be exerted in reanimating all the generations of mankind, now sleeping in the tomb; in producing a most wonderful change in the aspect of this terraqueous globe; and in causing "new heavens and a new earth" to arise, wherein righteousness shall dwell for ever. For that power which carries thousands of vast globes through the regions of immensity, with velocities of a hundred thousand miles in the short space of an hour, must be more than adequate to accomplish all the glorious scenes and transformations predicted in the records of the Christian revelation. The Christian may therefore rely with unshaken confidence on all the "great and precious promises" contained in the Scriptures of truth,

which are given forth by Him whose faithfulness is established in the very heavens, and who "keepeth covenant and mercy with them that love him and keep his commandments to a thousand generations," and therefore cannot fail of ultimately receiving their full accomplishment. Well, therefore, may the believer in Christ exclaim—

"If my immortal Saviour lives,
Then my immortal life is sure:
His word a firm foundation gives;
Here let me build and rest secure.

Here let my faith unshaken dwell:
Immovable the promise stands;
Nor all the powers of earth and hell
Can e'er dissolve the sacred bands.

Here, O my soul, thy trust repose!
If Jesus is for ever mine,
Not death itself, that last of foes,
Shall break a union so divine."

CHAPTER III.

DESCRIPTION OF THE SUN—OF THE INFERIOR PLANETS—AND OF THE EARTH AND MOON.

When we take a particular survey of the starry heavens, we find that the stars, in general, never shift their positions from each other. They appear to move round us in one compact body, as the figures of the constellations do on a celestial globe, when it is turned round its axis; but the stars belonging to one constellation never move toward those of another, nor change their distance from each other. If we direct our attention to the stars of the Great Bear, for example, (see fig. 1,) we shall find that, at all hours of the day and night, and at every season of the year, they present the same definite figure, and the same relative position to each other, without any sensible variation of distance or magnitude; and the same may be observed from one year to another. Hence, they are usually denominated "the fixed stars." But when we observe the heavens with still more accuracy and minuteness, we shall occasionally perceive a few bodies, having the appearance of stars, which, when carefully watched, for a few weeks or months, will be found

shifting their positions with respect to the surrounding stars. In most cases, their motion is toward the east, but not unfrequently toward the west, and, at certain times, no motion can be observed for a considerable number of days. The bodies which are thus perceived to change their positions among the stars are called PLANETS, which word signifies "wandering stars."

There are more than ten orbs of this description which have been traced in the heavens, and whose motions have been accurately ascertained. Only five of these bodies are visible to the naked eye; the other five can be seen only with telescopes. The five planets visible to the unassisted eye were known to the ancients, who gave them the following names, derived from the heathen mythology; namely—Mercury, Venus, Mars, Jupiter, and Saturn. The other five were discovered by means of the telescope, within the space of the last seventy years. They are named Vesta, Juno, Ceres, Pallas, and Uranus. By a careful investigation of the motions and other phenomena of these bodies, astronomers have ascertained that they all move round the sun as the centre of their motions; and, along with the earth, and nineteen smaller globes, form one grand and harmonious system, with which we who live on the terraqueous globe are

intimately connected. The central orb which enlightens these moving bodies, and by its influence preserves them in harmony and order, is the same sun that enlightens our day, and diffuses life and animation among all the animal and vegetable productions of our globe. These bodies, although they sometimes appear in different and even opposite regions of the heavens, occupy but a very small space, as to the range of their motions, compared with that which is occupied by the fixed stars. The whole assemblage of these moving orbs, including the earth, is what is generally denominated THE SOLAR SYSTEM, of which we shall now proceed to give a general description, beginning at the centre of the system, and proceeding to the different planets as they lie in order.

SECTION I.—*The Sun.*

The sun is the grand centre and the animating principle of the planetary system, around which all the planets revolve, at different distances, and in different periods of time; and by whose attracting influence they are retained in their respective orbits. From this source they all derive light and heat, and all the other influences requisite to fit them for being habitable worlds.

Among all the objects of the visible creation, there is none whose beauty is so much admired, and whose benign influence is so generally appreciated, as the sun. Every day this glorious orb visits us with its cheering beams, dispels the shades of night, and diffuses joy and animation among all the tribes of sensitive existence; without whose powerful energy our world would soon become a dark and shapeless chaos, without life, order, or enjoyment. But the splendor of this luminary, and the benefits it confers, are so common and so regularly continued, that we are apt to view them with indifference; and we seldom contemplate, with the eye of an enlightened understanding, the wonderful nature of that globe on which surrounding worlds depend for all the comforts and beneficial agencies they enjoy. To the vulgar eye, the solar orb appears only like a flat luminous circle of a few inches diameter; and there are thousands of mankind who consider it in no other light than as a brilliant lamp, of no great size, hung up in the firmament to give us light by day, and to enable us to prosecute our daily labors. Even minds of a more elevated and reflecting cast have seldom entered into all the sublime ideas connected with the nature and properties of this august luminary; and it is questionable whether the

greatest astronomer now existing is capable of forming a conception of the magnitude and sublimity of the solar orb, corresponding to its vast extent and its real grandeur, as the soul, and centre, and connecting principle of mighty worlds.

Of the *magnitude* of this stupendous globe arithmetical numbers can scarcely convey to us an adequate idea; but we may, in the first place, state its dimensions in numbers. Its diameter, or a line passing through its centre from one side to another, it is found would be 880,000 miles. Its circumference, or a line going quite round it, is 2,764,600 miles. Its surface contains 2,432,800,000,000 of square miles, that is, more than twelve thousand times the number of square miles on our globe. Its solid contents comprehend 356,818,739,200,000,000, or three hundred and fifty-six thousand billions of cubical miles; that is, 1,350,000 times the number of solid miles which the terraqueous globe contains; so that were one million three hundred and fifty thousand globes as large as the earth to be compacted into one globe, it would only equal the size of the sun! Some of these dimensions may be somewhat illustrated as follows: Suppose a person to move round the sun's circumference at the rate of forty-five miles

every day, it would require more than one hundred and sixty years before the circuit could be completed. Suppose one were to traverse the whole surface of this luminary, so as to pass over every square mile on its surface, at the rate of sixty miles a day, it would require more than a hundred millions of years before such an object could be accomplished. It is stated that the splendid view from Mount Etna comprehends a circle two hundred and forty miles in diameter, containing forty-five thousand two hundred and forty square miles. Now this is only the fifty-three millionth part of the surface of the sun; so that more than fifty-three millions of landscapes, such as beheld from the top of Etna, must pass before us ere we could contemplate a surface as extensive as that of the sun. Were we to suppose every such landscape to occupy two hours in the contemplation, it would require twelve thousand two hundred and seventy-five years—without the least intermission—or more than double the time which has elapsed since the creation, before the whole surface of this immense globe could be, in this rapid manner, surveyed. The magnitude of this luminary may also be illustrated from the following comparison: The earth contains about two hundred and sixty-four thousand millions of cubical

miles; the planet Jupiter is fourteen hundred times larger than the earth; Saturn is about a thousand times; and Uranus about eighty times larger than the earth: yet the sun is found to be more than five hundred times larger than those planets, and all the other planets, moons, and comets of the solar system taken together.

If it be asked why the sun appears so small to our eyes, if it is indeed so immense a globe, it is easily answered, that this is owing to its immense distance from our world. This distance is no less than ninety-five millions of miles,—a distance of which the mind can form only a very inadequate conception. It may be somewhat illustrated, however, as follows: A cannon ball, at its utmost speed, when it leaves the mouth of the cannon, is calculated to fly at the rate of about five hundred miles an hour; but it would require such a moving body—though flying continually with this velocity—twenty-one years and two hundred and forty-five days before it could reach the sun. This may be further illustrated by motions with which we are more familiar. Suppose a steam carriage to set out from the earth in the direction of the sun, and to move, without intermission, at the rate of four hundred and eighty miles every day, it would require five hundred and forty-seven

years before it could traverse the space which intervenes between us and that distant luminary. How wonderful, then, that the sun, at such a distance, should exert his attractive power upon the earth—fructify the soil—raise tides in the ocean—and diffuse light, and heat, and color, and animation, over all its regions! And not only so, but even on the remotest planet of the system, at the distance of eighteen hundred millions of miles, similar influences are produced by the agency of this august luminary!

Are we startled at the vast distance and dimensions of the solar orb which we have now stated? and are we apt to doubt whether the representations we have given be accordant with fact? We ought to consider that He who made the sun, and adorned him with the splendor he exhibits, is "THE LORD GOD OMNIPOTENT," the extent of whose power and wisdom none can comprehend; and that the sun required to be of such a magnitude to give stability to the system of which he is the centre; and, according to the laws he hath impressed upon the material world, to retain surrounding worlds in the paths prescribed them, and to dispense to them all those influences which they require. If we are astonished at the magnitude of the sun, how must our admiration be raised when

we consider that this globe is only one out of millions of similar globes which exist in the universe! For every star that adorns our firmament is, on good grounds, concluded to be a sun, no less spacious and luminous than that which enlightens our day; and has, doubtless, a retinue of planetary globes revolving around it, as the centre of light and influence.

Nature and Physical Constitution of the Sun.—Of the real nature of this luminary we have hitherto acquired but very imperfect conceptions. But since the invention of the telescope, our knowledge of its constitution has been somewhat enlarged. We no longer view the sun as a ball of liquid fire, as had sometimes been supposed, but as a solid body, composed of different materials, in which wonderful processes are going forward on an extensive scale, for preparing and perpetuating that light and heat which are destined to cheer and illuminate surrounding worlds. When the sun is viewed by means of a telescope, spots of various kinds are perceived upon its surface. These spots appear first on its eastern margin, when they appear narrow and somewhat obscure; they move gradually onward to the centre of the disk, when they appear largest and most distinct; afterward they proceed toward the western limb, where

they again appear narrow and obscure; and after a period of about thirteen days, from their first appearance on the eastern edge, they disappear from the western limb; and, in many cases, they again appear on the eastern limb, after the same period of thirteen days. But they are frequently somewhat changed in their aspect before they reappear; and, in numerous instances, after disappearing from the sun's western boundary, they are never again visible in the same shape; but other spots, at uncertain intervals, are seen diversifying the solar disk; though not unfrequently scarcely a single spot is to be seen over the whole surface of the sun. The spots appearing narrower and less distinct on the eastern and western limbs, is owing to our viewing obliquely these parts of the sun's surface. The conclusions to be deduced from these circumstances are: 1st. That the sun is a globe, and not a flat surface, as it appears to the naked eye, otherwise the spots would appear equally large and distinct on every part of its surface. 2d. That this luminary moves round its axis in the same direction as the rotation of the planets: for its spots do not shift their places on its disk, but are carried along with the whole body of the sun. The time of the apparent revolution of these spots is twenty-

seven days, eight hours; but the real period of the sun's rotation is twenty-five days, nine hours, fifty-six minutes; and therefore, the places about the sun's equator move at the rate of four thousand five hundred and thirty-two miles an hour.*

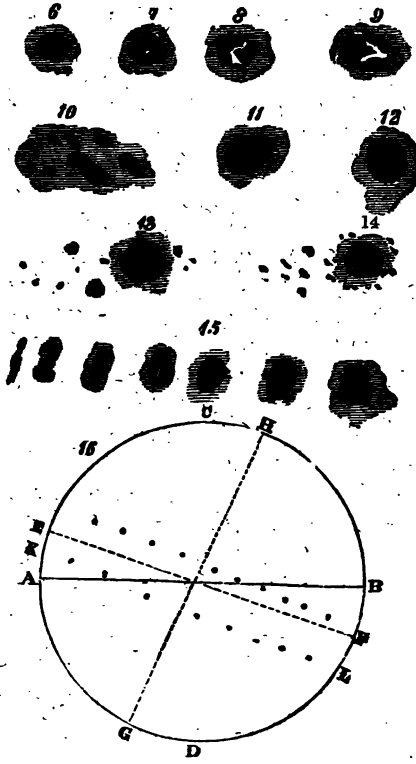
The solar spots are of all sizes and of different shapes: their size is from $\frac{1}{600}$ to $\frac{1}{30}$th of the sun's diameter. The smallest of those spots which can be distinctly seen are nearly a thousand miles in diameter. Spots, the one-fiftieth part of the diameter of the sun—which we have frequently seen—are 17,600 miles in diameter, or more than double the diameter of the earth; and if the spot be considered only as a plane, and somewhat circular, it will contain more than two hundred and forty-three thousand square miles, which is considerably more than the area of the whole terraqueous globe; and yet sometimes a spot of this vast size will disappear in a few weeks, and not unfrequently in a few days. Sometimes not a single spot is to be seen on the solar disk for weeks and even for months together; at other times we have

* This is found by dividing the circumference of the sun = 2,764,600 miles, by the number of hours in which the rotation is performed, namely 610 hours, and the quotient is the rate of motion per hour.

seen above one hundred spots of all sizes dispersed over the face of the sun at one time. In such cases, there are generally five or six large spots, such as that alluded to above, accompanied with ten, fifteen, or twenty smaller spots; after disappearing at the sun's western limb, it is seldom that they come round again in the same order as before. Some appear to have been altogether dissipated, and others to have changed their shape and relation to surrounding spots, in which they formerly appeared. We have seen spots of nearly 2,000 miles in diameter vanish in the course of twenty-two hours: and, on the other hand, on a late occasion, we beheld two spots, each of them larger than the earth, and containing at least three hundred millions of square miles, which were formed near the centre of the solar disk, where no trace of them was seen forty hours before; which circumstances show the amazing rapidity with which these mighty masses are formed, and again rendered invisible to the sight. The portions of the sun's surface where the spots most frequently appear, are those which lie adjacent to its equatorial regions; no spots being ever seen near its northern or southern poles. In some years these spots have been very numerous, and seldom a week has passed without

a few of them having been seen, while in other years comparatively few have been visible.

These spots, as to their general appearance, resemble a dark nucleus, surrounded with a penumbra, or belt of a lighter shade. This penumbra is generally of a shape nearly corresponding to that of the dark nucleus, or central spot. This fainter belt is plainly perceptible in the larger spots, and when very high powers are applied to the telescope, the umbræ are also visible in the smaller spots. The following representations will convey a general idea of the phenomena of the solar spots. Fig. 6 represents the more common appearance of these spots—a dark central part surrounded by a fainter shade. Figs. 7, 8, 9, represent the appearances of certain spots which exhibit a bright spot, or figure, in the midst of the dark nucleus. Fig. 10 shows a spot, in which various dark spots are surrounded by one common penumbra; figs. 11, 12, spots of different shapes; figs. 13, 14, large spots accompanied or surrounded with dark spots of a much smaller size. This is a very common phenomenon: it is seldom that any large spots are seen without being accompanied with a variety of small spots of different sizes, frequently assuming the appearance of a tail to the large spot. Fig. 15 represents the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appearance and progress of a single spot, from the time it appears on the sun's eastern limb till it arrive at the centre of the disk. As the sun moves round an axis which is not perpendicular to the ecliptic, but inclined seven and a half degrees from the perpendicular, so the spots move in a line deviating from the ecliptic, and perpendicular to the sun's axis. Thus in fig. 16, A B represents the ecliptic; D C its axis perpendicular to it; G H the axis of the sun, around which it performs its rotation, deviating seven and a half degrees from D C, the axis of the ecliptic. The spots therefore move in a line E F or K L, which is at right angles with the axis of the sun.

Besides the dark spots whose phenomena we have now described, there are spots which have a bright and mottled appearance, and which it is difficult, in most cases, to distinguish from the general body of the sun. They are chiefly to be seen when they first appear on the eastern margin of the sun, and when they approach near the western limb; but they are seldom or never seen near the middle of the disk. They are most generally seen in connection with clusters of the dark spots, and when they are first seen near the eastern limb they frequently indicate that dark spots are about to make their

appearance. They appear like numerous ridges, and plainly indicate that the sun is not a smooth surface, but is diversified with elevations and depressions, or, in other words, with mountains and vales of a stupendous size, otherwise we could not perceive them at the remote distance at which we are placed. But what these bright ridges, or corrugations, are—whether immense luminous clouds, or solid bodies; or what purpose they serve in the operations which are going forward in this luminary—we are unable to determine.

The following is a summary of the phenomena of the solar spots. 1. Every spot which has a dark nucleus has also an umbra surrounding it. 2. The boundary between the nucleus and umbra is well defined. 3. The increase of a spot is gradual, the breadth of the nucleus and umbra dilating at the same time; and its decrease is gradual in the same manner. 4. The nucleus, when on the decrease, in many instances changes its figure by the umbra encroaching upon it; and thus it sometimes happens that the nucleus is divided into two or more nuclei. 5. The exterior boundary of the umbræ never consists of sharp angles, but is always curvilinear. 6. The nucleus vanishes sooner than the umbra.

The conclusions which have been drawn from the phenomena now described, in reference to the constitution of the sun, are as follows: That the central part of the spots is beneath the level of the sun's surface, or, in other words, that the spots are excavations in the body of this luminary, and that the umbra, or shade, which surrounds it, is the shelving sides of this excavation in the luminous matter. According to this view, the nucleus is nothing else than the dark and solid body of the sun appearing through the openings of a luminous atmosphere which surrounds this mighty globe. According to Sir W. Herschel's estimate, this atmosphere is not less than 1,840 miles, and not more than 2,760 miles in depth. This he regards as the outermost coating of the sun, or his visible surface; and under this superior stratum, he conceived there is another, more dense and highly reflective, which throws back the light of the upper regions, and that this lower atmosphere constitutes the umbra of the spots, and that the dark central parts of the spots, or the nuclei, are part of the solid matter of which the sun's body is composed. In accordance with such views, the internal part of the sun may be considered as an immense solid ball, not altogether unlike the earth and the other planets; and there is no

great improbability in supposing that it is fitted for being the habitation of sensitive and intelligent beings, with constitutions adapted to the situation; and that it may constitute the most glorious habitation connected with the solar system. But whatever may be the real nature and constitution of this luminary, it is evident, from the rapid and extensive changes which are frequently happening both among the bright and dark spots, that there are forces of prodigious power in continual operation, producing the most astonishing effects, in a short space of time, sometimes in a few hours or minutes, on the surface or in the luminous atmosphere of this great central body. And such changes are, doubtless, necessary for preserving the present constitution of the sun—for enabling him to diffuse light and heat—and to act as the soul of surrounding worlds.

This magnificent luminary is the grand source of light, and heat, and color to this earth, and to all the planetary globes, with their rings and satellites, which belong to our system. By its energy and influence it cheers, adorns, and animates a retinue of mighty worlds; directing their motions, and preserving them all in the paths prescribed them, so that none shall wander from their course, or interfere with others. It

is the central bond which unites the moon to the earth; the satellites of Jupiter, Saturn, and Uranus, to their respective primaries, and all the other planets in one grand and harmonious system. On our globe, the benign effects of the sun are numerous and powerful. He is not only the source of illumination, but of all that beautiful diversity of coloring which adorns every terrestrial landscape. Both the earth and sea—the lowest depths of the ocean, and the darkest cavern—feel the effects of his powerful agency. All animated beings rejoice in his presence: when his rays dispel the shades of night, millions of the insect tribes awake and sport in his beams, the birds salute him with their melodious concerts, everything that breathes feels the effect of his influence; man watches for the morning, and rejoices at his approach; for "truly the light is sweet, and a pleasant thing it is for the eyes to behold the sun." The vegetable tribes likewise feel his energy: he gives circulation to the sap in plants and trees; he causes the blossoms and leaves to shoot; the hills and vales to be covered with verdure, and the fruits of the earth to ripen to a golden harvest, for supplying the wants of man and beast. Without the influence of this luminary, darkness and all its gloomy accom-

paniments would for ever involve this lower creation; all the beauties which now adorn the face of nature would be swept away, the birds would cease their warblings, the flowers would no longer be decked with the gayest colors, nor shed their rich perfumes. Life, activity, and animation, would soon cease; and the earth, ere long, would be transformed into a hideous chaos.

Can we reflect on the grandeur and magnitude of this luminary, and the manifold beneficial effects which it produces on our world, without raising our thoughts to Him who at first launched this vast globe from his almighty arm, and still sustains it in all its energies? In all our surveys of the system of nature, it becomes us to raise our views from the effect to the cause, from the creature to the great Creator, and to give to him "the glory due to his name." This is not only a duty inculcated in Scripture, but is in full accordance with the dictates of true philosophy; which declare, that every phenomenon, and every effect in the universe, should be traced up to a cause adequate to its production. And what cause could produce such a stupendous luminary, but that Being who existed from eternity, whose power is uncontrollable and illimitable, and whose "kingdom ruleth over all?" In the formation of this

spacious globe we behold a display of omnipotence which overwhelms our conceptions, and which shows us that nothing, however amazing and incomprehensible, can be beyond the limits of God's power to accomplish. In the numerous beneficial agencies produced by the sun, we have a display of his beneficence, an evidence that the happiness of his creatures is one of the main objects of his creating power, and that "his tender mercies are over all his works." "The day is thine; the night also is thine; thou hast prepared the light and the sun." He hath placed our world at such a distance from this luminary, as neither to dazzle us with excessive brilliancy, nor scorch us with excessive heat, nor freeze us with insufferable cold; but to produce an illumination and a temperature suited to the inhabitants of every clime. The man who can contemplate this glorious object, and feel all the beneficial effects of its influence, without the least emotion of gratitude, reverence, and adoration, scarcely deserves to enjoy the beneficence of his Creator. Let us, then, "give thanks unto the Lord—to him that made great lights—the sun to rule the day: for his mercy endureth for ever." And as the sun enlightens, cheers, and fructifies our globe, and distributes benefits wherever

he shines; so let us likewise, according to our power and opportunities, exert all our energies in imparting blessings to our brethren of mankind. As he daily sheds his benign influence around the world; as he rises for the benefit of the ungrateful and the unjust, as well as for the good and the righteous, so let our beneficence be displayed toward men of all characters and nations, that we may prove ourselves to be "the children of the Most High," who, without distinction of persons, distributes blessings without number among all the ranks of sensitive and intelligent existence.

Notwithstanding the numerous benefits which the sun dispenses to all the inhabitants of our globe, it is a melancholy truth that the greater part of its population is still involved in intellectual darkness and moral debasement, "being alienated from the life of God through the ignorance that is in them." In this respect it may still be said, as in ancient times, that darkness covers the earth, and gross darkness the majority of the people who inhabit it. While the sun diffuses its splendor around them, their minds are shrouded in a midnight gloom, into which "the light of the knowledge of the glory of God," as it shines "in the face of Jesus Christ," has never penetrated. Before

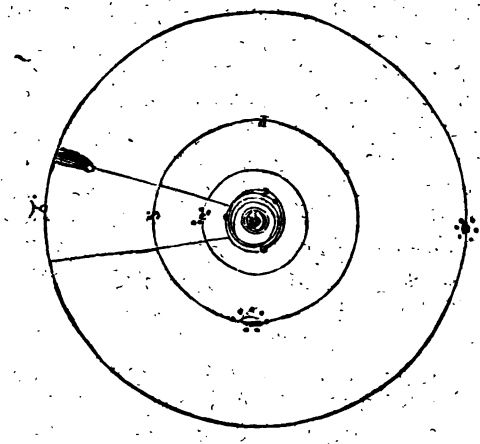
all the effects of light—material and mental—can be fully felt, the Sun of righteousness must arise on the nations "with healing in his beams," to diffuse knowledge, joy, and salvation. His influences are as necessary to our true happiness, as those of the material sun to our external comfort and existence.

His Spirit irradiates the darkest understandings, purifies the most debased affections, and diffuses gladness and consolation wherever the light of divine truth shines into the heart. And as the rays of this spiritual Sun are diffused by the truths of revelation, it is our duty to disseminate these truths as extensively as possible among all the kindreds, and families, and tribes, that dwell upon the face of all the earth. Wherever the natural sun shines, the light of divine truth should be made to shed its influence and its lustre, till light shall spring up to those who sit in darkness and the shadow of death; till "the glory of the Lord shall cover the earth, and all flesh see the salvation of God."

Section II.—*The Planet Mercury.*

Having given a general description of the sun—which is the centre of the planetary orbs, around which they all perform their revolutions, at different distances and in different periods of

time—we shall now proceed to give a brief description of what is most interesting in the phenomena of the different planets, beginning with that which is nearest the centre, and proceeding, in order, to those which are more distant. The order in which the orbits of the planets lie from the sun is represented in the following small diagram. The proportional



distances of the planets from the centre cannot be distinctly represented, unless upon a diagram of very large extent. In this small figure, the middle point represents the position of the sun. The inner circle next the point which repre-

sents the sun, is the orbit of Mercury, the nearest planet to the sun; the second circle represents the orbit of Venus; the third that of the Earth; the fourth that of Mars; the next circles, which cross each other, represent the orbits of the lately discovered planets: Vesta, Juno, Ceres, and Pallas. Beyond these, the next circle represents the orbit of Jupiter with his satellites, and next to that the orbit of Saturn. The outermost circle is that of Uranus, sometimes distinguished by the names of Herschel, and the Georgium Sidus.

These orbits appear very small, as delineated in this diagram; but they are in reality so immensely large, that the mind can scarcely form any adequate conception of them. The orbit of Mercury, which is the smallest, is more than two hundred and thirty-two millions of miles in circumference. Were a steam-carriage to move around it at the rate of twenty miles an hour, it would require more than one thousand three hundred and twenty-four years before it could complete the circuit; yet the planet itself moves around it in the short space of eighty-eight days. The orbit of Uranus, the most distant planet of the system, is eleven thousand three hundred millions of miles in circumference, and three thousand six hundred

millions in diameter. To move round this circumference, at the rate of thirty miles an hour, would require above forty-two thousand nine hundred years, or more than seven times the period which has elapsed since the creation of Adam; while the planet itself moves round it in eighty-four years. So that all the arrangements of the divine Being are conducted on a scale of magnificence, astonishing to mortals, and corresponding to the infinite majesty and grandeur of Him "who stretched out the heavens by his understanding."

The narrow curve, on the left hand of the figure, crossing the orbits of the planets, represents a portion of the orbit of a comet. The comets move in all directions through the solar system, and their orbits consist of long narrow ellipses, or ovals, some of which extend far beyond the orbits of the most distant planets, where they sometimes remain for a long series of years. These bodies are distinguished by their dim, dusky, and ruddy light, and the long tails, or trains of light, with which they frequently make their appearance. Sometimes they are visible to the naked eye, and make a splendid appearance; but numerous bodies of this description pass near the centre of our system, which are only visible by means of

telescopes, and numbers, doubtless, which are never distinguished even by astronomers, except when by chance they happen to direct their telescopes to those portions of the heavens in which they are moving. From December, 1843, to September, 1844, no less than three comets were discovered, but not one of them was visible to the unassisted eye.

Having made these preliminary remarks respecting the general arrangement of the planets and comets, we proceed to a brief description of—

The Planet Mercury.—This planet, as already noticed, is the nearest to the sun; at least, no planets nearer this luminary have yet been discovered, though it is not improbable that one or two may exist within the orbit of Mercury. Its name signifies "the swift messenger," and, in point of fact, it is the swiftest moving planet in the solar system, its rate of motion being, at an average, one hundred and nine thousand eight hundred miles an hour, or one thousand eight hundred and thirty miles in a minute; but its rate of motion is somewhat different in different parts of its course, as it moves in an elliptical orbit. Its distance from the sun is about thirty-seven millions of miles, and it performs its revolution around that luminary in eighty-seven days, twenty-three hours, and twenty-five

minutes. As to *magnitude*, this planet ranks among the smaller bodies of the system. Its diameter is three thousand two hundred miles, its circumference ten thousand and fifty-three miles, and its surface contains above thirty-two millions of square miles, which is considerably less than the habitable parts of our globe. Were we to compare its size with that of the sun, we should find that it would require nearly twenty-two millions of globes of the size of Mercury to form a globe equal to that of the sun.*

This planet always appears to move in the neighborhood of the sun. It never appears above twenty-nine degrees distant from the sun, and frequently at the period of its greatest elongations it is not above sixteen or seventeen de-

* This is estimated in the following manner:—The comparative bulks of spheres are to each other as the cubes of their diameters; therefore, divide the cubes of their diameters by each other, and the quotient shows the number of times the one is contained in the other. In the present instance, multiply the sun's diameter, 880,000 miles, twice into itself, and divide the product by the cube of the diameter of Mercury, 3,200 miles, and the quotient will give the number of times that the sun is larger than this planet. Thus the cube of 880,000 is 681,472,000,000,000,000, which divided by 32,768,000,000, the cube of Mercury's diameter=21 millions and five-sixths, nearly.

grees from that luminary. On this account, it is difficult to be distinguished by the naked eye, unless near the periods of its greatest elongations. The time between its greatest elongations from the sun, varies from one hundred and six to one hundred and thirty days. When it is at its greatest elongation east of the sun, it is seen in the evenings, at a low elevation, not far from the point where the sun sets. When it is west of the sun, it is seen in the morning not far from the point of sunrise. The most favorable seasons for observing it are the spring and autumn, as it is in a higher declination at those seasons than in winter, and the twilight is not so strong nor so long continued as in summer. When viewed by the naked eye, it appears to emit a very white light; and those who would wish to get a view of this planet, when it may be seen, should inspect an almanac, or ephemeris, where the times of its elongations are distinctly stated. When viewed with a telescope, it appears, in the course of its revolution round the sun, to pass through all the phases of the moon, sometimes appearing as a half-moon, sometimes as a crescent, and at other times with a gibbous phase. When it appears of a half-moon or cresent phase, its enlightened side, like that of the moon, is al-

ways turned toward the sun, which proves that it is in itself a dark body, and derives all its light from that luminary. On account of its nearness to the sun, few discoveries have been made on its surface by the telescope. It has been observed, however, that when it appears as a crescent, one of its horns is truncated, or cut off at the point, by which the period of its revolutions round its axis has been determined, which is supposed to be accomplished in twenty-four hours and five minutes. This truncature is doubtless the effect of elevations and depressions on its surface; and hence, some astronomers have concluded that mountains of considerable elevation exist on Mercury, one of which is calculated to be eight English miles in perpendicular altitude. It is supposed, likewise, that it is enveloped with an extremely dense atmosphere.

In consequence of its nearness to the sun—being nearly three times nearer than the earth—the quantity of light is nearly seven times greater than what we receive; and the sun will appear to a spectator in that planet about seven times larger than to us—which circumstances will cause a more brilliant lustre to appear on all the objects on the surface of this planet than appears on the scenery of our globe. Such

eyes as ours would be unable to sustain so dazzling a brightness, unless their pupils were contracted to the diameter of one-fiftieth of an inch. That the quantity of heat is in the same proportion, or seven times greater than on the earth, is an opinion by no means probable. It is more probable, from many circumstances connected with our own globe, and from a variety of experiments which have been made on the subject of heat, that the sun's rays may be modified in their action by the nature of the atmosphere, and the constituent elements of which the planet is composed. It is probable that sensible heat depends chiefly on the distribution of the substance of caloric, or the principle of heat, on the surfaces, and throughout the atmospheres of the planets, in different quantities, according to the different situations they occupy in the solar system; so that it is possible there may be no more sensible heat felt on the surface of Mercury than on that of the earth, or even of Saturn, or Uranus.

Mercury revolves in an elliptical orbit, which is more eccentric than the orbits of the other planets, except Juno and Pallas. This is the reason why, at some of its greatest elongations, it is only sixteen degrees from the sun; while at others, it is nearly twenty-nine degrees distant. Its eccentricity, or the distance of the

sun from the centre of its orbit, is above seven millions of miles; which is about the one-tenth part of the diameter of its orbit; and this orbit is inclined to the ecliptic, or the planet of the earth's orbit, in an angle of seven degrees, so that it is sometimes this number of degrees above the level of the ecliptic, and at other times as much below it. The density of this planet is greater than that of any other planet of the system. It has been estimated to be nearly twice the density of the earth, that is, about nine times the density of water, or nearly equal to that of lead. Such conclusions are deduced from the laws of gravitation, by which all the planets are directed in their motions.

Transits of Mercury.—At certain periods, this planet is observed to pass across the sun's disk, like a small dark spot. This can happen only at the time of its inferior conjunction with the sun—when it is nearest to the earth—when its enlightened side is turned toward the sun, and its dark hemisphere is turned directly toward the earth; and when the earth, Mercury, and the sun, are nearly in one straight line. This passage of Mercury across the solar disk is called its transit, and is considered by astronomers as an interesting phenomenon. If the orbit of this planet were in the same plane with

that of the earth, it would transit the sun's disk at every inferior conjunction, or three or four times every year. But as its orbit is inclined to the ecliptic, a transit can happen only when it comes to the inferior conjunction, at the time it is at or near its nodes, or the points where it crosses the ecliptic, and when the earth is in the same longitude, and this occurs only at intervals of several years. The last visible transit previous to 1845 happened in 1832, another happened in November, 1835, but was invisible in Britain, as the sun was set before its commencement. A visible transit likewise occurred on May 8th, 1845, which began at nineteen minutes past four P. M., Greenwich time; and the planet arrived near the centre of the disk at thirty-five minutes past seven P. M.; but before the planet's egress from the sun's western limb, the sun set to the inhabitants of this country. The next visible transit of Mercury will happen at the following periods: 1848, Nov. 9th; 1861, November 12th; 1868, November 5th; 1878, May 6th. The other transits, during the present century, in 1881, 1891, and 1894, will be invisible in Britain and other European countries, but will be seen in several parts of North and South America, and the islands of the Pacific Ocean.

This planet, notwithstanding its comparative smallness, forms a portion of the divine empire, and is capable of containing a population larger than even that of our globe. Though diminutive in its appearance, and seldom seen by the inhabitants of the earth, we can scarcely doubt that there are to be found on this planet millions of sentient and intelligent beings—perhaps far superior in dignity to man—with constitutions fitted for that sphere in which Providence has placed them, and with mental powers which qualify them to know, to love, and to adore their great Creator. For it may be considered as an axiom, that the material universe was created, and is still preserved in existence, chiefly for the sake of sensitive and intellectual natures, to afford them the means of happiness, and to give them a sensible display of the character and attributes of the eternal Divinity.

Section III.—*The Planet Venus.*

Next to Mercury, in the order of the system, is the planet Venus. To the naked eye it appears the most beautiful and splendid star in the heavens, and has been distinguished both in ancient and modern times as the morning and evening star, because in one part of its course,

it makes its appearance, in the west, in the evening, before any other star is visible; and, in another part of its course, it appears in the east in the morning, ushering in the dawn, and giving notice of the approach of the rising sun. Its distance from the sun is reckoned at sixty-eight millions of miles, being thirty-one millions of miles from the orbit of Mercury, and about twenty-seven millions of miles from the earth at its nearest approach to it. At this distance it is nearer the earth than any other celestial body can approach, the moon only excepted. In respect of *magnitude*, it is found to be 7,800 miles in diameter, or very nearly the size of our globe. Its surface contains one hundred and ninety-one millions of square miles, and the quantity of light it receives from the sun is nearly double that which falls upon the earth, on account of its greater nearness to the sun, so that that luminary will appear from its surface twice as large as it does to us. From a variety of observations which have been made on this planet, it appears that it has a rotation on its axis, which is accomplished in the period of twenty-three hours, twenty-one minutes; and as the period of the earth's rotation is twenty-three hours, fifty-six minutes, its day is, of course, thirty-five minutes shorter than ours.

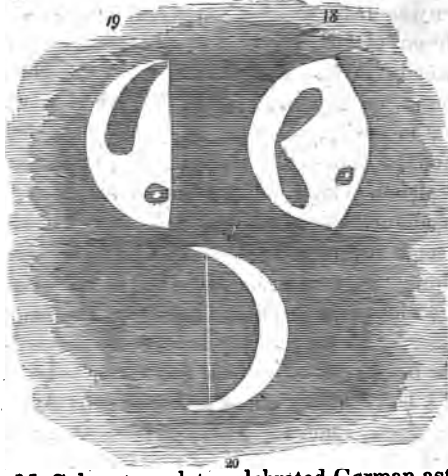
Discoveries made on Venus by the Telescope.—The first time the telescope was directed to this planet was in the year 1610, by the celebrated Galileo, who had just a little before constructed one of the first telescopes. The chief discovery he then made was, that this planet, in the course of its revolution round the sun, passed through all the phases of the moon, sometimes appearing as a crescent, or like the moon when three or four days old, sometimes like a half-moon, and at other times with a gibbous phase, or like the moon three or four days before the full. That the planet presents such phases to our eye is a plain proof that it does not move round the earth as its centre of motion, as the ancients supposed, but round the sun, in an orbit which lies within the orbit of the earth. For if it moved in an orbit exterior to that of the earth, it never could present to us either a half-moon, or a crescent phase. At the period to which we allude, the greater part of the learned had adopted the vulgar opinion which so long prevailed, that the earth is at rest in the centre of the universe, and that all the planets revolve around it. It was objected to the Copernican system, which supposes the earth to be one of the planets—and which had been recently broached—that if this were the case, the planets

Mercury and Venus would appear with all the phases of the moon. This was fully admitted; but it could never be exhibited to the organs of vision before the telescope was invented. When Galileo had published this and several other discoveries, the senators of Venice, who were most of them eminent for their love of learning, invited this astronomer to come, and in their presence make a trial of his new instrument. He complied with their request; and, on a fine, clear, and serene evening, mounted his telescope on the tower of St. Mark, and showed them several of the discoveries he had made, and particularly the appearance of Venus, which was then near the point of its greatest elongation from the sun. One senator after another beheld the planet through the telescope, and all were surprised that more than half of its hemisphere was obscured; that it did not appear round as most of the other heavenly orbs, but inclining to a crescent, with points, or horns, at its opposite sides. Upon this Galileo proceeded to show how this phenomenon furnished a demonstrative proof of the Copernican system of the universe. That night was fatal to the ancient systems maintained in the schools; and from that period, the true system of the world began to be recognized by all intelligent and unprejudiced minds,

and in the midst of every opposition, to be extensively propagated through the world.

After the telescope was improved, and its length and magnifying powers increased, more particular observations began to be made on the surface of Venus. Cassini, an Italian astronomer, with instruments of a large size, on October 14th, 1666, at five hours forty-five minutes P. M., saw a small bright spot, near the section between the dark and bright side of the planet; at the same time, he noticed two dark oblong spots, nearer the other side of the disk, as represented in fig. 18. On the 20th of April, 1667, in the morning, a little before sunrise, he perceived, on the disk of the planet, then half enlightened, a bright spot near the section and toward the lower horn; and nearer to the northern horn he saw a darkish oblong spot, as represented in fig. 19; and after sunrise he perceived that the bright spot was advanced considerably from the southern horn; and from this and several subsequent observations, he had a plain proof of the rotation of the planet, which he afterward determined to be in the space of somewhat more than twenty-three hours. For many years after this period, we have few recorded observations of these spots; and, indeed, they are very difficult to be perceived, on ac

count of the extreme brilliancy which this planet exhibits, and the undulations of the atmosphere, when viewed at a low altitude in the evening. The best time for viewing the surface of this planet is in the daytime, when it is near the meridian, by means of large equatorial telescopes.

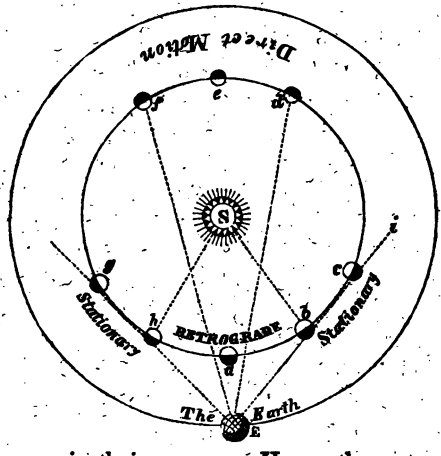


M. Schroeter, a late celebrated German astronomer, made a variety of observations on this planet, from which he has deduced several important conclusions. He dicovered the twilight of Venus, or the stretching of a faint light be-

yond the semicircle which ought to be alone directly enlightened, as shown at fig. 20, where the cusps, or horns, seem to stretch into the dark hemisphere. He deduced from this, and other observations, that Venus has an atmosphere of considerable extent, the densest part of which is above three miles high. A similar conclusion was deduced by a variety of observers in different places, when viewing the transit of this planet in 1761. At the time when the planet entered on the sun's disk, and when it was about to emerge from the eastern limb, a faint penumbra or dusky shade was seen surrounding the planet, which indicated an atmosphere of considerable height. M. Schroeter likewise detected several mountain ridges, and elevations of great magnitude, on the surface of Venus. Such elevations are ascertained from the length of their shadows. He estimated the perpendicular height of one of these mountains to be ten and a half English miles, and of another no less than nineteen miles. Although these elevations so far surpass the height of the highest mountains on our globe, yet such estimates are not to be considered on this account as improbable. For, in nature, there is an infinite variety, and every planet differs from another in its arrangements. Such lofty elevations will add to the

sublimity of nature on the surface of this planet, and will afford, from their sumits, prospects far more extensive and sublime than we can at present conceive.

Apparent Motions of Venus.—Were the planets viewed from the sun, the centre of the system, their motions would appear nearly uniform, and in one direction, from west to east. But when viewed from the earth, or any other planet, their motions appear very irregular, and in different directions, and sometimes they appear to make



a pause in their course. Hence the apparent motions of the planets, as viewed from the earth,

are said to be either direct, retrograde, or stationary. This may be illustrated in the apparent motions of Venus, and what is here stated of this planet will equally apply to the motion of Mercury. Thus, in fig. 21, let S represent the sun, E the earth, and *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, the planet Venus in different parts of its orbit, as seen from the earth at E. When it is at *a*, it is said to be in its inferior conjunction with the sun, because it is then nearly in a line with the sun; and were it visible, it would be seen nearly in the same part of the heavens as the sun. But at this time its dark hemisphere is turned toward the earth, and therefore is invisible unless it should happen, as it sometimes does, to pass across the disk of the sun. In moving from *a* to *b*, its motion is retrograde, or toward the west. In moving from *b* to *c*, it appears stationary, because the tangent line, or visual ray *b i*, will appear for some time to coincide with the orbit of the planet. At *c* the planet is said to be at its greatest western elongation from the sun, when it appears in its greatest brightness as a morning star. In passing from *c* to *d*, and from *d* to *e*, its motion is direct, or from west to east. At *e* is the point of its superior conjunction, when it is again nearly in a line with the sun, and when its full enlight-

ened hemisphere is turned toward the earth. But at this point it is the whole diameter of its orbit, or one hundred and thirty-six millions of miles, further from the earth than when it was at *a*, and therefore appears smaller near this position than when only the one-fourth of its enlightened side is seen. From *e* to *f*, and from *f* to *g*, the motion is still direct; from *a* to *h*, it is again stationary, and from *h* to *a* retrograde.

In regard to the *phases* of Venus we may add the following remarks. When the planet is at *e*, at its superior conjunction, if it could then be seen,* it would present a full enlightened hem-

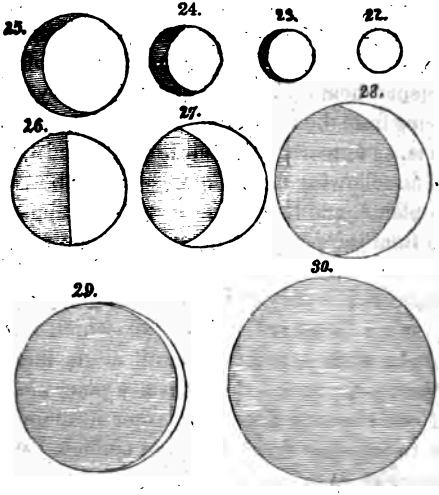
* It has been frequently asserted by astronomical writers that this planet cannot be seen at its superior conjunction. The author of this volume, however, in the course of his observations on the heavenly bodies in the daytime, had an opportunity, on the 2d of October, 1843, of seeing this planet within a few minutes of the time of its superior conjunction, when it was only fifty-eight minutes, or less than one degree, from the sun's margin. It was viewed with a three feet and a half achromatic telescope, magnifying ninety-five times, and appeared round and pretty distinct, though partly immersed in the solar rays. This circumstance proves that the surface of Venus reflects the solar rays with peculiar brilliancy, more than that of any other planet. For a more particular account of this observation, see "Edinburgh New Philosophical Journal" for January, 1844.

isphere. As it moves from *e* to *f*, it gradually comes into view as an evening star, and at first appears very low near the point of the horizon where the sun sets. Its motion appears slow on account of its distance from the earth, and it is sometimes two or three months, after passing the point of its conjunction, before it becomes distinctly visible to the naked eye. When it comes to the point *f*, it exhibits a gibbous phase, as seen by the telescope. As it moves onward toward *g*, its apparent size increases, and its gibbous phase gradually declines to that of a half-moon. At *g* it appears like a half-moon inclining to a crescent. About this point of its orbit is the period of its greatest brilliancy, and in certain years, when in this position, it may be seen in the daytime by the naked eye. At the point *h*, it appears of a crescent form, and while moving from *h* to *a*, the point of its inferior conjunction, its crescent becomes more slender, but at the same time more expansive, till it appears like the crescent of the moon when she is less than two days old. At *a* the dark side of the planet is turned toward the earth, and consequently invisible. The period employed in passing through these changes, from *e* to *a*, is about nine months and a half. In passing through the other semicircle from *a* to *b*, *c*, *d*, *e*,

it becomes a morning star, and, a few days after the conjunction, is seen in the east preceding the rising sun. In proceeding from *a* to *b* and *c*, its apparent motion is rapid, and it presents a crescent phase; at *c* it appears like a half-moon, and in the remaining part of its course to *e* its phase is gibbous, till it arrives at the superior conjunction, when it again presents a full enlightened hemisphere. The time employed in moving from the inferior to the superior conjunction is, as formerly, about nine months and a half.

The following figures represent the phases of this planet, and its gradual increase of apparent size from the period of its superior conjunction to its inferior. Fig. 22 is its phase as a full enlightened hemisphere, and its proportional size when compared with fig. 30, which represents it, when nearest the earth at its inferior conjunction. At this time, it is five times nearer, and consequently five times larger in diameter, and twenty-five times larger in surface, than it appears at its superior conjunction. Figs. 23, 24, 25, represent different degrees of its gibbous phase; 26, its half-moon phase; 27, 28, 29, its crescent phase; where it will be seen, that as the breadth of the crescent diminishes, its expansion and length increase, as it is then approaching nearer the earth. Fig. 30 represents its

dark side turned toward us at the inferior conjunction. In moving from the inferior to the superior conjunction, it passes through all these phases in a reverse order. First it appears as 29, then as 28, and till it arrives at the phase fig. 22.



We shall state only the following additional facts respecting this planet. The period of its revolution round the sun is in 224 days 16 hours, during which time it accomplishes a course of 434 millions of miles, at the rate of eight thousand miles an hour. Its orbit is

inclined to the ecliptic in an angle of three degrees twenty-three minutes and a half, and the eccentricity of its orbit is less than half a million of miles, or about the 1-276th of its diameter. On the ground of certain observations, it has been supposed that it is attended with a satellite; but such a body, if it exist, is seldom seen, and therefore its existence is considered as uncertain. In its elongations, it never removes further from the sun than from forty-five degrees to forty-seven degrees. If its enlightened side were turned toward us when it is nearest the earth, it would present a surface twenty-five times larger than it generally does, and shine with the splendor of a small moon; but, at that time, its dark side is turned to the earth. To an inhabitant of Venus, Mercury will appear as a morning and evening star, with more splendor than it does to us; and the earth, when nearest to Venus, will shine forth with a splendor nearly ten times greater than either Jupiter or Venus does to us. This planet, like Mercury, sometimes makes a transit across the disk of the sun. The last transit happened in 1769, and the next will take place on December 9, 1874, at eight minutes past four, A. M., which will be invisible in Britain, and in most European

countries; but, as it is a phenomenon of great importance in astronomy, British astronomers will, doubtless, be sent to observe it in those countries where it will be visible.

This beautiful planet, distinguished from all the other stars by its superior brilliancy, is occasionally alluded to by the sacred writers, as the "son of the morning"—"the day star," and "the bright and morning star:" emblematical of the Redeemer of mankind, giving light to the world after a long night of superstition and darkness, and of its cheering influence on the minds of sinful men, when the "day star" from on high hath arisen in their hearts. When viewing the bright luminaries of the sky, and especially the morning star, and when we consider the beautiful order and arrangement of these orbs, the placid influences they diffuse, and the harmony with which all their movements are performed, a contemplative mind can scarcely refrain from contrasting such scenes with the darkness and disorder which prevail in the moral world. While the sun diffuses his splendors by day, and the moon and the stars shed their mild radiance by night, it is still necessary to the happiness of our world that intellectual light and sacred joy should be diffused over the minds of its inha-

bitants—of which the light of these luminaries is designed to serve as an emblem. When the morning star makes its appearance near the eastern horizon, it is a sign that the sun will, ere long, arise, and that the darkness of night will soon be dispelled. When the "day star" arises on the benighted mind, it intimates that gloom and darkness, with all their miserable accompaniments, formerly brooded over it: but now that the light of divine truth has begun to irradiate the darkness, it is a sign that this light will still increase, and shine "more and more unto the perfect day," till at length it blend itself with the glories of the celestial world, where the "sun shall no more go down," where the Lord God shall be an everlasting light, and where the days of darkness and "mourning shall be ended."

SECTION IV.—*The Earth; considered as a Planetary Body.*

(1.) *General View of the Earth's Surface, Atmosphere, Magnitude, and Method of finding its Dimensions.*

It may seem strange to some readers that this world on which we reside should be considered a planetary orb; as, at first view, it appears to bear no resemblance to any of the orbs that

appear in our nocturnal sky. The planets, as they are seen in the heavens by the unassisted eye, appear only as comparatively small points of light; whereas the earth, from whatever point it is viewed, appears the largest body our eyes can anywhere behold, and when we traverse its surface, either by sea or land, there appear no boundaries to its dimensions. From the positions in which we are permitted to view any portion of the earth—even when we ascend several miles above its surface in balloons—it exhibits no luminous aspect such as that which the celestial bodies present; so that, at first view, we might be apt to suppose that no similarity can exist between our sublunary world and the orbs of heaven. Besides, the celestial orbs are apparently in rapid motion from one region to another, while the earth, as a whole, appears to be at rest in the centre of the celestial motions. Whether we sit in our apartments, or walk in the fields, we feel no motion in the solid earth which supports us, and are apt to imagine that the portion of the globe on which we dwell remains invariably in the same point of infinite space. We perceive no motions connected with our world but those which are produced by the rivers, the ocean, the atmosphere, and subterranean concussions,

and those which are the result of the various processes of the arts—the flux and reflux of the sea—the flowing streams—the roaring cataracts—the stormy winds—the waving forests—the ships moving on the face of the deep—and the steam-carriages, with their hundreds of passengers, flying along the railway course. There is not, perhaps, one out of a thousand of the earth's inhabitants that has the least conception that—besides every other movement of which he is susceptible—he is carried along through the regions of infinite space with the rapidity of thousands of miles every hour. Yet this is a fact which is not merely probable, but certain, and can be demonstrated to the conviction of every one who is willing and qualified to enter into such investigations.

Could we take our station on the surface of the moon, we should behold the earth hanging like a great globe in the firmament, appearing with a surface about thirteen times larger than the moon does to us, and turning round its different sides to our eye—sometimes presenting the view of America and the Pacific Ocean, and at other times Asia, Africa, Europe, and the Atlantic—sometimes appearing like a large crescent, or half-moon, and at other times with a full enlightened hemisphere. Were we placed

on the surface of Venus, we should behold the globe on which we live appearing in the azure sky like a large bright star, as that planet appears to us when an evening or morning star; and the moon, which appears so large in our firmament, would be seen only like a very small star, very near the earth, and constantly moving around it. At certain times, the earth would appear nearly ten times larger than Venus does to us, and would present the appearance of a small brilliant moon. Were we placed on the planet Mars, which is much further from the sun than Venus, the earth would appear alternately as a morning and evening star, exhibiting different phases, as Venus does to us, but with a less degree of size and splendor. It might not, perhaps, shine with so much brilliancy as Venus, but it would probably appear with a lustre similar to that which Mars presents to us. Nor need it be wondered at that the earth should appear as a luminous body from such distant positions; for we have demonstrative proof that Venus, Mars, and all the other planets, though they appear like shining orbs, are in reality dark bodies like the earth, and have no light of their own but what they receive from the sun; and it is only when the portions of their sides which are enlightened by the sun

are turned to us that they are seen in the heavens. On some occasions, the dark side of Venus is completely turned toward the earth, and then she is invisible; and sometimes, when in this position, has been seen, like a dark spot, to pass across the face of the sun. These and other circumstances demonstrate that the planets are in themselves dark bodies, and shine only by reflection; and consequently that the earth, though a dark body, will appear to shine at a distance by reflecting the solar rays which fall upon it, as the moon does to us.

We have already proved, that, as a planet, the earth turns round its axis every twenty-four hours; and, in the sequel, we shall endeavor to show that it also moves round the sun in company with the other planets. In the mean time, we may take a brief view of the surface of our globe, which, in some of its features, may, perhaps, resemble those of some of the other planetary worlds.

When we cast our eyes around us, and take a general survey of the surface of the earth, thousands of objects present themselves to the view which demand attention. One of the most obvious and common arrangements which we behold in almost every country, is the verdant covering of the earth, which is formed by an

assemblage of herbs, plants, shrubs, and trees of various shades, which diversify the landscape, and refresh the organs of vision; for there is no color so pleasing, and which refreshes the eye so much, as the various shades of green. When we enlarge the circle of our view by traveling through different countries, we behold objects of a more grand and magnificent description; ranges of mountains, hundreds of miles in length, with their summits rising above the clouds, presenting a scene of rugged grandeur and sublimity; rivers, rolling their vast masses of waters, in courses of hundreds or thousands of miles toward the ocean, in which they are absorbed; the ocean itself, in its numerous windings, spreading its immense sheet of waters over more than half the globe, rising and subsiding at certain intervals, and forming a medium of communication between the most distant regions of the globe. In various regions of the earth, we behold expansive lakes and inland seas diversified with numerous islands, lofty and abrupt precipices, capes, and promontories, dashing cataracts, unfathomable caverns, rapid whirlpools, avalanches hurling down the declivities of lofty mountains, the icebergs of the polar regions, the luxuriant scenes of the torrid zone, and numerous volcanoes sur-

rounded with smoke, and pouring forth from their craters ashes, flames, red-hot stones, and streams of melted lava on the surrounding regions.

When we contemplate our globe in its largest and most general features, we find its surface divided from north to south by two large bands of earth, and two still larger bands of water, which exhibit a somewhat irregular appearance presenting a number of wavings and indentations, and a great difference of breadth in different places. The first band of earth is the Eastern Continent, comprehending Europe, Asia, and Africa, the greatest length of which is in a line beginning about the northern part of Tartary, and extending to the Cape of Good Hope, or from A to B, fig. 31, which line measures about ten thousand miles from north-east to south-west. This body of land contains thirty-six millions of square miles, forming nearly one-fifth of the surface of the terraqueous globe. The other band of earth is the Western Continent, which comprehends North and South America. Its greatest length is in a line from the mouth of the river Plata, in South America, to the land beyond Hudson's Bay, or from C to D. This line measures eight thousand miles; and the whole of this continent contains fourteen mil-

lions of square miles, being little more than one-third of the western continent. South-east of the western continent is a large body of land, which may be considered as a third continent; namely, New-Holland, which is two thousand four hundred miles in length, and one thousand eight hundred in breadth, and contains nearly three millions of square miles. Besides the bands of earth now specified, there are numerous extensive portions of land dispersed throughout the ocean, such as the islands of Madagascar, Sumatra, Borneo, New-Guinea, Great Britain, Ireland, and hundreds of others.

Between the two large continents now mentioned lie two immense bands of water, which are called the Pacific and the Atlantic Oceans. The Pacific is at least eleven thousand miles from north to south, and ten thousand miles in breadth from east to west. The Atlantic is about three thousand miles broad from east to west, and more than ten thousand miles in length from north to south. It lies between the western shores of Europe and Africa, and the eastern shores of America. The Pacific occupies the whole range between the western coasts of America and the eastern coasts of Asia, occupying nearly one half of the globe. The relative positions of these continents and oceans

Fig. 31.

E
Pacific Ocean
Southern Ocean
South
North
Atlantic Ocean
Atlantic
Africa
Asia
Southern Ocean
Indian Ocean
South
North
A

will be seen by an inspection of fig. 31, where it may be noticed that the projections of the eastern side of the American continent nearly correspond with the indentations of the western side of the eastern continent; so that if we could conceive the two continents brought together, they would nearly correspond, so as to form one compact continent, with two or three small gulfs between them. The following are nearly the dimensions of the different oceans. The Pacific covers eighty millions of square miles; which is far more than the extent of all the dry land on the face of the earth. The Atlantic covers twenty-five millions; the Indian Ocean thirteen millions; the Southern Ocean twenty-five millions; the Northern Ocean five millions; the Mediterranean one million; the Black Sea one hundred and seventy thousand square miles; the Baltic one hundred and seventy-five thousand; the North Sea one hundred and sixty thousand. And if, as La Place has estimated, the tides demand an average depth of three miles, the whole ocean will contain four hundred and fifty millions of cubic miles. The whole surface of the ocean, then, contains about one hundred and forty-nine millions of square miles, which is more than three times greater

than the surface of the land, which contains only forty-nine millions of square miles.

Around this vast body of land and water the Creator has thrown an atmosphere, or body of air, which is as essential to the existence and comfort of the living beings that dwell on its surface, as any other arrangement respecting our world. The denser part of this body of air extends to the height of about forty-five miles above the surface of the earth, but its density gradually decreases in proportion as we ascend into its higher regions; and at a certain height it is unfit for respiration and giving play to the animal functions. This atmosphere, though almost impalpable to our senses, is now ascertained to be a compound substance, composed of two very different and almost opposite substances, as to their qualities. One of its ingredients, which forms about four-fifths of the whole atmosphere, is of such a nature that no fire will burn in it, and if man or other animals breathe it, life is almost instantly extinguished. The other ingredient, which forms only one-fifth of the atmosphere, is the principle of combustion, and produces the most rapid and splendid deflagration of all combustible substances, and even a steel wire, or a thin file, if plunged into this

species of air, will take fire and burn with the utmost brilliancy. Animals might breathe it for some time without much annoyance; but it would soon waste the functions of the animal system. It is by an admirable combination of these two opposite principles that the air we breathe is constituted; and in this combination, the wisdom and goodness of our beneficent Creator are clearly manifested; for had these principles been combined in a very different proportion, pain, suffocation, or death, might have been produced in all animals that breathed it. It is in this atmosphere that the birds fly, and the clouds are suspended—where rain, hail, and snow are formed—where a portion of the ocean, of the seas, and of the rivers, is continually ascending, to form those clouds which water and fructify the earth—it is the medium in which whirlwinds rage, and lightnings flash, and thunders roll; and were it swept from the earth, or were its constituent principles materially changed, every living being would soon disappear from all the regions of earth, air, and sea. Were the Creator disposed to destroy the human race on account of their transgressions, he has only to extract one of the ingredients which compose the atmosphere which surrounds us, and the awful catastrophe is at once accomplish-

ed; so that, in his "hand is the soul of every living thing, and the breath of all mankind." But his forbearance in this respect is a palpable evidence that he is "slow to anger," "merciful and gracious," "abundant in goodness," and that "his tender mercies are over all his works."

In regard to the *magnitude* of the earth, it may be stated that its circumference, or a line going quite round it, measures about twenty-four thousand nine hundred and twelve miles; and, of course, its diameter, or a line passing from one side to another through its centre, measures seven thousand nine hundred and thirty miles,* and the number of square miles on its surface is about one hundred and ninety-seven millions. It has been ascertained, by various experiments

* As the circumference of a circle or globe is found by mathematicians to bear a certain definite proportion to the diameter—when the one is known the other is easily determined by calculation. The proportion of the circumference of a circle to its diameter is nearly as 22 to 7—more accurately as 3.1416 to 1. Therefore, if we multiply the circumference by 7, and divide the product by 22, we obtain the diameter, nearly. And if we multiply the diameter by 22 and divide by 7, we obtain the circumference. But we obtain the result more accurately by multiplying the diameter by 3.1416, in order to obtain the circumference; and by dividing the circumference by 3.1416, to obtain the diameter.

and measurements, that the earth, strictly speaking, is not exactly of the shape of a globe, but of an oblate spheroid, being somewhat flattened at the poles, and having its polar diameter about twenty-six miles shorter than the diameter passing through the equator. But the difference is so small, compared with the whole bulk of the earth, that though a spheroid were constructed of the exact shape of the earth, and fifteen feet in diameter, it could not be distinguished by the eye from a common globe.

To some readers it may appear somewhat strange that we should speak with so much confidence of the bulk and dimensions of the world we live in, which has never yet been completely explored; and they may, perhaps, wish to know how it is possible to determine its magnitude, figure, and other properties and relations. It must be confessed that to measure the earth, and determine its magnitude, and its exact figure, is one of the most wonderful enterprises which has ever been undertaken by man. How shall a creature, only six feet high, whose longest measures are yards, poles, and chains, be able to traverse every region of this great world, and measure its dimensions? His stature and his longest measures are, when compared with the whole earth, but as a grain of

sand to a range of mountains. Besides, there are portions of the earth which have never yet been reached either by sea or land; and although he were to carry his measuring lines along with him, and extend them to furlongs, miles, and leagues, yet he could not go round the circumference of the earth to obtain its exact measure. Mountains, rivers, seas, and oceans, and many other obstacles, would be continual impediments in his way, and would soon put an entire stop to his progress, and the attainment of his object. But, notwithstanding such difficulties, man, by the exercise of his rational powers, and the knowledge he has acquired of the positions and motions of the heavenly bodies, has been enabled to determine, to a very near approximation, the exact dimensions of his earthly habitation, without putting himself to the trouble of traveling to the most distant regions, or even removing from the land of his nativity.

When the earth was ascertained to be nearly of a globular figure, and when the method was discovered of finding the distance of any place from the equator;* or, in other words, its lati-

* The equator is a great circle of the earth, equally distant from the north and south poles, and divides the globe into two equal parts, called the northern and south-

tude, a foundation was laid for finding the circumference and other dimensions of the globe. Every circle, or every circumference of a sphere, whether great or small, is divided into three hundred and sixty equal parts. This number, three hundred and sixty, is arbitrary, and any other number, such as four hundred, six hundred, or one thousand, might have been fixed upon; but mathematicians, in most countries, have fixed upon three hundred and sixty as the number of degrees or divisions in a circle; because, in the first place, it was formerly supposed to be about the number of days in a year, and in the next place, because it is a number that may be divided into halves, quarters, and eights, without fractions. Now, in order to obtain the dimensions of the earth, it was only necessary that one degree on its surface should be accurately measured in order to obtain the whole circumference. To accomplish this, we must draw a meridian line—that is, a line that runs directly north and south, at any place we make choice of for the first station, and find the latitude or height of the pole at that particular place. We must, then, prolong the meridian

ern hemispheres. From this circle the latitudes of places are counted, either northward or southward. It is represented by the line E Q_1 in fig. 31.

line, either northward, till we come to a place where the latitude is exactly one degree more —or southward, till it is one degree less than at the first station. We must, then, measure the distance between these two places, in miles, leagues, yards, or any other known measures; and then we obtain the number of miles, etc., contained in one degree, or the three hundred and sixtieth part of the earth's circumference; and the number of miles, etc., contained in one degree, being multiplied by three hundred and sixty, gives the whole circumference of the earth. And when the circumference is obtained, the diameter may be found by the rule given in the preceding note, (p. 155.) And when the circumference and diameter are known, the number of square miles on its surface, and the number of cubical miles in its solidity, may be obtained by an easy calculation. But although one degree accurately measured would determine the dimensions of the earth, yet more accuracy is obtained by measuring three, five, eight, or ten degrees, as has been done by several European nations.

On the general principle now stated, Mr. Richard Norwood, in the year 1635, attempted to find the circumference of the earth by measuring a meridian line between London and

York. He took the sun's altitude when it was in the summer solstice, both at London and York, with a sextant of eight feet radius, and by that means found the difference of latitude between these two cities to be two degrees and twenty-eight minutes. He then measured their distance, in as exact a manner as possible; and having taken into the account all the turnings and windings of the road, with the ascents and descents, he reduced it to an arc of the meridian, and found it to contain 12,849 chains; and this distance being compared with the difference of latitude, gave 5,209 chains, or 367,200 English feet to a degree, which is equal to sixty-nine and a half miles and fourteen poles, and which was considered as a near approximation to the truth, according to which the circumference of the earth would be about 25,035 miles. Since his time various admeasurements have been made of different parts of the earth's surface, from which its extent has been still more accurately ascertained. The French have measured a meridian line extending from Dunkirk to Formentara, an island in the Mediterranean, an extent of about eight degrees; and a trigonometrical survey, for the same purpose, under the direction of the British government, has lately been extended over Great Britain. From

all the admeasurements hitherto made, it appears that, on an average, a degree of the meridian may be reckoned at sixty-nine and one-fifth English miles, which makes the circumference of the globe 24,912 miles. It may just be noticed further on this point, that, as the earth is not an exact sphere, but a spheroid, a degree of latitude must measure more in the polar regions than near the equator. From actual measurements, it has been found that a degree of the meridian in Lapland measures six and a half English furlongs more than a degree at the equator.

(2.) *Proofs of the Annual Motion of the Earth.*

We have formerly demonstrated the diurnal rotation of the earth, which causes the appearance of the rising and setting of the sun, moon, and stars. We now proceed to state very briefly some of those considerations or arguments by which it is proved that the earth revolves round the sun, as the centre of the system, once every year.

In the first place, there are certain general considerations that render it highly probable, if not certain, that the earth must have a motion round the sun. If we admit the annual motion of the earth, then all the phenomena of the heavens, and the apparent irregularities of the plan-

etary motions, are completely accounted for, and the whole system presents a scene of unity, harmony, and order, worthy of the perfections and the plans of Him who is "the only wise God,"—who "hath established the world by his wisdom, and hath stretched out the heavens by his understanding." Whereas if the earth be supposed at rest in the centre of the system, the order and harmony of the solar system appear completely destroyed, the motions of the planets present an inextricable maze, their phenomena cannot be accounted for on any rational principles, and no evidence of wisdom can be traced in the arrangements of the system to which they belong. Again, the sun is the fountain of light and heat for irradiating and cheering all the planets and other moving bodies of the system, and therefore it is necessary that this luminous orb should be placed in the centre, from which position alone its rays can be distributed in proper proportions to all the worlds which revolve around it. Were the earth at rest in the centre of the system, and the sun and the planets revolving around it, as was formerly supposed, the planets would be at certain times at very different distances from the sun; and consequently, in one part of their orbits

they would be scorched with superabundant heat, and in another part frozen with insufferable cold. But from the centre of the system the emanations of light and heat can be equally distributed to all the planets, whether primary or secondary; and the whole presents to view a system of harmony and order.

The following summary of arguments on this point—did our limits permit us to explain and illustrate them—would appear demonstrative to every one who is acquainted with the subject. 1. The planets Mercury and Venus are observed to have two conjunctions with the sun, but are never in opposition to that luminary, that is, they are never seen in the east, or opposite part of the heavens, when the sun has just set in the west. Now this circumstance could not possibly happen, unless the orbits of these planets lay within the orbit of the earth. If they revolved around the earth as a centre, as the ancients supposed, they might frequently be seen in opposition to the sun. 2. The greatest elongation, or distance, of Mercury from the sun is twenty-nine degrees; and the greatest elongation of Venus, or the distance to which it ever recedes from the sun, is forty-eight degrees, which correspond exactly with the distances

assigned them in the system; but if they moved round the earth as a centre, they would sometimes be seen one hundred and eighty degrees from the sun,—a circumstance which was never observed either in ancient or modern times. 3. The planets, Mars, Jupiter, and Saturn, and all the other superior planets, have each their conjunctions with the sun, and oppositions to him, which could not be unless their orbits were exterior to the orbit of the earth. 4. In the arrangement of the planets—according to the system which places the sun in the centre—they will be sometimes much nearer the earth than at other times; and, consequently, their brightness and apparent diameters will be proportionally greater at one period than at another, which corresponds with every day's observations. But according to the system which places the earth in the centre, their apparent magnitudes should always be the same, which is contrary to fact; the planet Mars, for instance, being in one part of its course five times nearer the earth than in another, and consequently appearing twenty-five times larger in surface. 5. All the planets, in their movements through the heavens, are seen sometimes to move toward the east, sometimes toward the west; and at certain points of their orbits, they appear fixed

for some time in the same position; all which diversities of apparent motion are the necessary results of the earth's annual motion, and are completely accounted for, when the sun is considered as the centre of the system, and the earth as revolving between the orbits of Mars and Venus. But they are altogether inexplicable, on the supposition that the earth is at rest in the centre of the system. 6. When the planets Mercury and Venus are viewed through good telescopes, they are found to assume different phases, in different parts of their orbits, sometimes appearing gibbous, sometimes like a half-moon, and at other times like a crescent, or a full enlightened hemisphere—as formerly explained; which could never happen, if they revolved round the earth as their centre, and if the earth were not placed in an orbit exterior to that of Venus. But such phases are the necessary result of this position of the earth in the solar system. 7. The law discovered by Kepler, that "the squares of the periodic times of the revolutions of the planets are in proportion to the cubes of their mean distances from the sun," is a law which is established on the most accurate observations, and by which all the planets, both primary and secondary, are regulated. For example, Venus revolves round

the sun in two hundred and twenty-four days, and the earth in three hundred and sixty-five, and the mean distance of the earth from the sun is ninety-five millions of miles. Hence, as the square of 365 = 133,225, is to the square of 224 = 50,176, so is the cube of 95,000,000 = 857,375,000,000,000,000,000 to a fourth number, which is the cube of the mean distance of Venus from the sun. And if the cube root of this number be found, it will give about sixty-eight millions of miles for her real mean distance. But this law, which applies to all the heavenly bodies without exception, is completely set aside and destroyed, were the sun and planets to be considered as moving round the earth as the centre of their motions. In short, were we to suppose the earth at rest in the centre of the planetary system, the motions of all the planets would present a scene of inextricable confusion —a scene of such disorder and confusion, as would puzzle not only man, but the most intelligent archangel to account for, and to explain in consistency with the perfections of a Being of infinite wisdom and intelligence.*

* Those who would wish to see a full illustration of the above arguments are referred to a work, entitled "Celestial Scenery, or the Wonders of the Planetary System Displayed;" where these and several other

The most complete and sensible demonstration of the annual motion of the earth is furnished by Dr. Bradley's discovery of "the aberration of the light of the fixed stars." In endeavoring to determine the annual parallax of the stars, he discovered that they are not motionless, but that, during the time the earth takes to traverse its orbit, such of them as are in a plane perpendicular to this orbit, appear to describe circles. This is the phenomenon called "the aberration of light," which is found to be the motion of light combined with the progressive motion of the earth in its orbit, which causes the stars to be seen in a different position from what they would be if the eye were at rest. But as the explanation of this phenomenon would require some minute details, and several figures for its illustration, and as it might not be understood by general readers, we will defer in the mean time from entering upon any further statements. We may just remark, that the fact of the aberration of the stars exhibits the motion of the earth to our senses as clearly as if, from a fixed point in the heavens, we actually beheld it pursuing its course through the ethereal regions.

arguments are illustrated in minute detail, and by reference to engravings.

It is of importance that we acquire clear and convincing views on this subject, in order that we may entertain correct and honorable conceptions of the perfections of the Creator, and of the wisdom and intelligence displayed in the arrangements of his works. For, in all cases, we judge of the character and perfections of the designer and workman from the qualities and perfections which appear in their works. If we view the works of the Almighty through a distorted medium, we shall be apt to entertain incorrect and distorted views of the attributes of Him who designed and formed them. If we view the earth as at rest in the centre of creation, and the sun, moon, planets, comets, and stars—in other words, the whole universe—revolving around us every day, with motions so rapid as to exceed all calculation and comprehension; or if we suppose the planets moving backward and forward without any order, and presenting in their motions a series of looped curves and mazes without any marks of design, and exhibiting a scene of inextricable confusion; we should scarcely be led to entertain high and honorable conceptions of the wisdom of Him who formed such arrangements; for the marks of divine intelligence, on such suppositions, would nowhere appear. Whereas, in the true

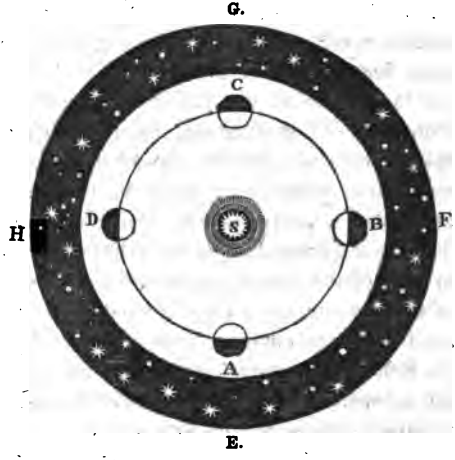
system of the universe which science has laid open, the marks of wisdom and intelligence, harmony and design, are everywhere apparent, and present a scene of operation worthy of the perfections of Him who "established the world by his wisdom," and whose "understanding is infinite." Hence the necessity of acquiring correct views of the works of creation and providence, and of the arrangements which exist in reference to our world, and to the universe around us; for upon such views our conceptions of the great object of our adoration will, in a great measure, depend. When, therefore, we obey the divine command, and "lift up our eyes on high, and behold the wonders of Almighty Power," and "stand still and consider the wonderful works of God," we are to contemplate them, not through the mists of ignorance, or vulgar prejudice, nor with the vacant stare of a savage; but with the eye of a Christian philosopher, and through the light which modern science has diffused over the wonders of creation; and the more we contemplate them in this light, the more clear and expansive will our conceptions be of the attributes of the "high and lofty One who inhabiteth eternity," and who presides over all the wonderful movements of the universe.

(3.) *Phenomena arising from the Annual Motion of the Earth.*

In the first place, if the earth revolve around the sun once every year, it is evident that the sun will appear to make a revolution round the heavens in the same period. In fig. 32, let S represent the sun at rest in the centre, and A B C D the earth in four positions; and let us suppose the earth to move in the order of the letters A B C D: it is evident that when the earth is at A, the sun will appear in that part of the heavens where the stars at G are situate. When the earth has moved to B, the sun will appear to have moved to the stars opposite H; and in like manner, when the earth has moved to C, the sun will appear opposite to E; and when it has moved to D, the sun will appear at F; after which it will again appear at G, when the earth has moved to A. And as the earth revolves around the sun in the orbit A B C D, so the sun will appear to a spectator on the earth to describe the circle in the heavens E F G H. Hence it is that we see the sun gradually proceeding in his course round the concave of the sky from west to east at the rate of nearly one degree every day, through the twelve signs or constellations of the zodiac; and at the end of a year he returns to the same point from

which he set out. Hence also it follows, that if the plane of the earth's orbit be imagined to be extended to the heavens, it would cut the starry firmament in that very circle in which a

Fig. 32.



spectator in the sun would see the earth revolve every year, while an inhabitant of the earth would observe the sun to go through the same circle in the same space of time. This circle is called the ecliptic, or the apparent path of the sun through the heavens. And, although

the path of the sun, and the particular stars he is passing along, cannot be seen in the daytime, yet, from observing the stars that are directly opposite to him at night, we can tell at any time what particular stars the sun is passing along in every part of his course.

The inhabitants of all the other planets will perceive similar motions in the sun as we observe, but performed in different periods of time, according to the times of their annual revolutions. For example, an inhabitant of Jupiter would see the sun apparently revolving around him, describing a circle in the heavens in the space of twelve years. This circle would not be exactly the same as our ecliptic, because the orbit of this planet is somewhat inclined to the orbit of the earth; but it would pass very near it. In the course of one of our years the sun, from Jupiter, would appear to pass through only a twelfth part of the circumference of the heavens. The sun from Saturn will appear to move in another circle in twenty-nine years and a half; and a spectator in Venus will see the sun moving in a circle different from all these, with greater apparent rapidity, in the space of seven and a half months. All these apparent motions of the sun arise from the real motions of the respective planets.

In the next place, the annual revolution of the earth shows the reason why we behold one set of stars in our firmament at one season of the year, and another set of stars at a different season. For example, in our latitude, the stars and constellations which are seen during the winter months, in the south, are altogether different from those which are seen in summer; and those stars which surround the pole in the north, and which never set, if they are below the pole in winter, they will be seen as far above the pole in summer. At the equator, where all the stars rise and set, the stars which appear in the middle of winter are all completely different from those which are seen at the same hour in the middle of summer. This is easily explained by the preceding diagram, (fig. 32,) in which the earth, in four situations in its orbit, appears half enlightened and half in the dark, representing day and night. When it is at A, the sun will appear at noon at G, and obscure all the stars in the hemisphere F G H; whereas at midnight the point of the heavens E will be in the meridian, and all the stars in the other hemisphere F E H will be visible. Three months afterward, when the earth comes to the situation B, the sun at noon

will be seen at H, and all the heavens G H E will be day, illuminated by the sun; and over all the other half, E F G, the stars will shine at night. Consequently, the stars in the quarter F G will now be visible, which, in the former position, were obscured by the sun, and those in the quarter H E, formerly visible, will become obscured by daylight. In like manner, when the earth is at C, the heavens H E F will be day, and F G H night, where all the stars which were obscured, when the earth was at A, will now be visible. And, lastly, when the earth is at D, the stars and constellations in the hemisphere E F G will be obscured by the light of the sun, and those on G H E will be visible during the night. Hence, every one who is accustomed to look at the heavens will have observed that the bright constellation Orion, the brilliant star Sirius, which follows it, and the Pleiades, or seven stars, which are visible in the southern part of the firmament during winter and the approach of spring, are never seen during the summer months, because the sun is then illuminating that portion of the heavens where they are situate; but they may be seen in the daytime by means of equatorial telescopes.

(4.) *On the Destination of the Earth, or the final Cause of its Creation.*

In the creation of the material universe, the Creator must have had some grand designs in view, besides the mere formation of immense globes of matter and setting them in motion, and arranging them into systems. In so far as we are able to penetrate, it appears demonstrable that matter exists chiefly, if not solely, for the sake of sentient and intellectual beings. This evidently appears to have been the chief design for which our globe was created; and we have the strongest reason to conclude that this was the main end for which all the other planetary globes, belonging to the solar system and to other systems, were brought into existence. Hence it is declared in the sacred oracles, when reference is made to the formation of our globe, "God formed the earth and made it;—he created it not in vain; he formed it to be inhabited;" which evidently implies, that to have created it without the design of its being inhabited, would have been an instance of folly inconsistent with the perfections of Him whose wisdom and intelligence are infinite; and the same reasoning will apply to all the other planets, which appear to be furnished

with every accommodation adapted to sensitive and intellectual enjoyment.

In peopling the earth and other globes with inhabitants, the Creator evidently intended to give a display of his perfections to beings capable of contemplating it, and to promote their sensitive and mental enjoyment. The happiness of his creatures must have been one grand design which the Creator had in view, when he breathed into them the breath of life, and made them rational and immortal beings. Accordingly, we find that when man was at first placed upon this globe, everything that was beautiful to the eye and the imagination, and pleasant to the taste, was prepared for his accommodation and comfort. The waters were separated from the dry land—the earth was adorned with verdure—rivers and refreshing streams flowed around him to increase his pleasures—trees, plants, and flowers of every form and hue, diversified and embellished the landscape. Light was formed, and celestial luminaries appointed to diffuse its radiance—a canopy was thrown around his habitation adorned with thousands of shining orbs, to elevate his contemplations to other provinces of his Creator's dominions—every plant and tree yielding delicious fruit was provided to

gratify his taste, and afford him sustenance; and all the inferior ranks of sensitive existence were placed under his dominion. One chief design of the Almighty, in these arrangements, was to show man his dependence, to make him an adorer, and a being capable of knowing and honoring his Creator and bountiful Benefactor. He gave him a law which implied supreme love to his Maker, and obedience to his will; and as an external sign of his obedience, he said to him, "Behold all the trees of the garden in which I have placed thee; of every one of them thou mayest freely eat—but of the tree of knowledge of good and evil thou shalt not eat of it." This reserve—which has been so frequently objected to—did, in reality, constitute the chief glory of man. None of the inferior animals knew their origin or their Benefactor, they could give no testimony of gratitude, nor could they exhibit any shadow of religion. Man alone was elevated to a rank, and endowed with faculties so as to know to whom he is indebted for all his enjoyments—and he alone was taught to express his gratitude to the Giver of all good! This constituted the true glory of man, and his superiority over all the other tribes of sensitive existence. It was a great and honorable prerogative conferred upon him

to be able to obey his Benefactor, and to adore the hand which had loaded him with blessings: and, therefore, it was proper that a visible emblem of his obedience, or the contrary, should be continually before his eyes. The supreme Creator stood in no need either of the fruit of a certain tree, or of the opinions or sentiments of man respecting it. But it was fit that man should make an express profession of his gratitude and veneration: and, therefore, the sole exception which God made in his first transaction with man, was at once the memorial of his gratitude, and the public expression of his piety and submission to the divine will.

But we know that man did not remain in his primeval state of innocence and happiness, but by his disobedience "brought death into the world, and all our woe." For proof of this position, we have no need to enter into long trains of reasoning, or even to appeal to the records of revelation. The fact of man's fall and disobedience is written on the whole history of our world from the earliest ages to the present time. For what does the history of all nations chiefly record? It presents to our view little else than wars and commotions, contentions and animosities, and "garments rolled in blood." One nation rising up against another,

carrying fire and sword, and all the engines of destruction into a peaceful territory—laying waste provinces, burning cities, turning fruitful fields into a wilderness, and slaughtering, with diabolical fury, thousands and tens of thousands of their fellow-men. This has been one of the chief employments of all the tribes and nations that have ever dwelt on the face of the earth; and this fact, of itself, is a sufficient proof that man is no longer in his primeval condition of paradisiacal innocence and rectitude, but is fallen from his high estate, and his glory turned into shame. We trust there is not another instance of creatures endowed with rational faculties, and formed after the divine image, acting in this way, to be found among all the other worlds of the universe. And were we not accustomed to witness such infernal passions and atrocities, and to behold men glorying in that which is their shame, we should be filled with utter astonishment and wonder that such horrible actions should be perpetrated on each other by brethren of the same family, children of the same Father, and beings destined to an immortal existence.

But the benevolent Father of all did not intend that this moral derangement should be universal and perpetual. As soon as man had

fallen from his allegiance to his Maker, he displayed his character as a God of mercy, and ready to forgive. He declared that the seed of the woman should bruise the head of the serpent—that an illustrious Messenger, invested with divine power and authority, should be sent into the world at a proper time, to repair the ruins of the fall; "to finish transgression, and to make an end of sins;"—to bear the sins of many, and make "intercession for the transgressors." Preparatory to the advent of this divine Messenger, certain families were selected, in which the knowledge of the true God might be preserved—a certain nation, before whom astonishing miracles had been displayed, was chosen as the depository of divine revelations—a ceremonial worship was instituted, prefigurative of the events and blessings of Messiah's reign; prophets were raised up to announce the coming of the great Deliverer, and the glorious results of his administration—the events of divine Providence toward the nations were overruled and directed in such a manner as to bring about the advent of the promised Messiah in all the circumstances which prophets foretold, and which God had appointed; and, when the predicted period had arrived, a retinue of celestial messengers was dispatched

from heaven to earth to announce the appearance of "the Son of the Highest," of the increase of whose government there should be no end, and to proclaim "glory to God in the highest, and on earth peace, good-will toward men." And when this Deliverer appeared on the public theatre of the world, he exhibited the most convincing proofs of his divine mission by the most astonishing and beneficent miracles, displaying his power over the laws and the elements of nature—the spirits of darkness, and the disorders of the human frame—"healing all manner of sickness and disease;" causing the deaf to hear, the blind to see, the lame to walk, and the tongue of the dumb to sing—raising the dead to life, and recalling the departed spirit from the invisible world. And, at length, when the great Sacrifice for the sins of men was about to be offered, a series of the most august and striking supernatural events attended its accomplishment—the sun was clad in black, the heavens were arrayed in sackcloth, darkness for three hours covered the whole land, the veil of the Jewish temple was rent in twain from the top to the bottom, the earth trembled and shook, the rocks rent asunder, the graves were opened, and many bodies of saints that slept in the tombs arose to life.

On the third morning after this solemn scene, the "Prince of peace" arose victorious from the grave, showed himself openly to competent witnesses of his resurrection; and afterward, rising above the confines of this earthly ball, winged his flight on a resplendent cloud, attended by myriads of angels, through distant regions which "eye hath not seen," and entered into heaven itself, there to "appear in the presence of God for us."

In consequence of these astonishing and benevolent arrangements, all men, everywhere, are now commanded to repent, with the full assurance that they shall obtain pardon, peace, and reconciliation, and every blessing requisite for their happiness in the present world and in the life to come. For thus runs the message of the Most High to all the children of men:— "God so loved the world, that he gave his only begotten Son, that whosoever believeth in him should not perish, but have everlasting life." "Whom God hath set forth to be a propitiation through faith in his blood, to declare his righteousness for the remission of sins." "This is the record, that God hath given to us eternal life, and this life is in his Son." These announcements are made to all the inhabitants of this world, however vile, and however atrocious the

deeds they may have committed—to the ferocious warrior that has slaughtered thousands, and to those who have long wallowed in the mire of depravity and licentiousness, as well as to those who have manifested some external decency of conduct. For He who is exalted as a Prince and a Saviour, "is able also to save them to the uttermost that come unto God by him." And if we believe the record of God, and rest upon it as the declaration of a faithful Creator, we shall endeavor "to abound in all the fruits of righteousness"—to cultivate love toward God and toward man—"to add to our faith, virtue, knowledge, temperance, patience, brotherly kindness, and charity," and every other Christian disposition and virtue which will tend to prepare us for the intercourses and employments of that higher sphere of existence where all is peace, and harmony, and love.

One reason why the benevolent arrangements which have been made for the happiness of man have been so long kept hid from the greater part of the world, and moral evil has been permitted to abound, doubtless is, that an extensive and impressive display might be given of the dismal and miserable consequences which necessarily flow from refusing allegiance to the Most High, and from a violation of his laws—

to serve as a warning not only to the inhabitants of our globe, but to the inhabitants of other worlds, of the necessity of submitting to the will of the Supreme, and of the inevitable, disastrous effects which flow from the prevalence of moral evil. For if the fundamental laws of heaven—love to God and to man—were to be reversed, or universally violated, misery would pervade the whole moral universe, although it consisted of millions of worlds; and happiness could never be enjoyed by any rank of intelligent existence. But however dismal a scene may have been presented to view in the ages that are past, we are assured that a period is approaching—foretold by inspired prophets—when the world shall be regenerated, when "wars shall cease even to the ends of the earth;" when slavery and oppression, and all unrighteousness, shall be undermined and destroyed; when "the kingdoms of this world shall become the kingdoms of our Lord, and of his Christ;" when "every one shall sit under his vine and fig-tree," without the least fear of annoyance; when "the earth shall be full of the knowledge of the Lord, as the waters cover the sea," and "the Lord God will cause righteousness and praise to spring forth before all the nations." Then the antipathies of nations shall be destroyed; "the earth

shall yield her increase;" its desolate wastes shall be cultivated, and its ruins restored, and all people "shall dwell in a peaceable habitation and in sure dwellings, and in quiet resting-places." And when the purposes of divine Providence shall have been fulfilled in regard to the present state of our globe, its constitution shall be changed, its elementary parts dissolved; and "new heavens and a new earth" shall arise, wherein righteousness shall for ever dwell. Such is the destination of our world, and such are the arrangements which its Creator has made in reference to its inhabitants.

Some readers may, perhaps, be disposed to say, "What has all this theological dissertation to do with astronomy? we do not see that it has any connection with a description of the solar system." On this point we beg leave to differ from such objectors. What is the material universe, when separated from its reference to the Creator, and its relation to intelligent beings? A mere machine, which displays nothing but uncontrollable power, acting at random, without the least trace of wisdom, benevolence, or rectitude. To view the planetary system, or other systems, as consisting merely of a number of large globes, wheeling round their axes, and round their suns, in certain periods of time, is to

overlook some of the grandest and most interesting objects of astronomy. To suppose all the orbs of heaven to be self-existent and self-moving is absurdity and atheism; and to suppose the Creator to have formed them merely as so many august and splendid pieces of machinery, without any relation to intellectual natures, is inconsistent with every idea we ought to form of the attributes of the Divinity. The relation of the material system to intellectual beings ought, therefore, to be connected with astronomical investigations. We know not, indeed, the physical and moral characteristics of the inhabitants of Venus, Jupiter, or other planets; but we know, for certain, that if they be in a state of primeval innocence and happiness, they obey the two grand principles of the law prescribed to the inhabitants of our world—"Love to their Creator, and love to one another"—without the observance of which precepts, true happiness cannot be enjoyed in any world in the universe, and the whole material creation would be nothing else than a boundless Pandemonium. We know that these precepts have been generally violated in our world; and hence the wars, devastations, insurrections, systems of slavery and iniquity, and other evils, which have produced so much misery and wretchedness among

the population of our globe. And shall it be considered as improper and unphilosophical, that, in describing the material fabric of the world, those arrangements which the Almighty has formed for the regeneration of society, and the happiness of the human race, should be occasionally adverted to and detailed? We must demur to such a sentiment. Philosophy has been too long dissevered from its connection with religion—to which it ought ever to be allied; and it is now high time that every department of human knowledge should be studied in connection with the moral arrangements of the Almighty, the renovation of the world, and the eternal destiny of man. The sciences, when disjoined from such connections, lose the greater part of their value, and can be considered as useful only in reference to the concerns of this world, and the transitory duration of the life of man. Whereas, when studied with right views, and in all their legitimate connections and relations, they bear an intimate relation to the Divinity, to the progress and expansion of the human mind to other worlds, and to the scenes and employments of an immortal existence.

In reference to the earth, we shall now only state the following circumstances: The number of inhabitants which people the earth at one

time is estimated at eight hundred millions—of these five hundred millions are reckoned to Asia; fifty-eight millions to Africa; forty-two millions to America; and two hundred millions to Europe. Of these assemblages of human beings, twenty-five millions die every year, sixty-eight thousand every day, two thousand eight hundred and fifty every hour, and forty-seven every minute; so that at almost every pulse that beats within us, an immortal being is passing from time into eternity, from this visible and material world to another scene of existence—a solemn and important consideration to every one of us who must shortly follow, in our turn, the generations that have gone before us. If we reckon thirty-two years as the average period for a generation, as has been generally done—at the end of which period the whole human race is renewed, with a few exceptions—it will follow, that one hundred and forty-six thousand two hundred millions of human beings have existed on our globe, since its present arrangement commenced, reckoning 5849 years from the formation of Adam to the present time. But if we make our estimate according to the Samaritan and the Septuagint chronology, 7256 years are to be reckoned from Adam to the present time; and consequently, if mankind had

never died, there would have been, at present, on the surface of the globe, 182,800,000,000; that is, one hundred and eighty-two thousand eight hundred millions of human beings. Whether the earth would have furnished subsistence for such a population is left to Malthusians and political economists to determine. But it appears, in point of fact, that the Creator never intended that such a number of the human species should remain on the earth at one time, in its present state; though it might easily be shown, that, were all the habitable parts of the globe properly cultivated, it would support at least sixteen thousand millions of human beings, or twenty times the number that now exist on its surface, while each family would have an estate of twelve acres of land for its support. But the inferior tribes of animals are far more numerous than the amount of all the human inhabitants that have ever dwelt on the earth, from Adam to the last new-born child. At a rude calculation, the inferior tribes connected with the air, the waters, and the dry land, at one time, cannot amount to less than thirty billions of living beings; which is one hundred and sixty-four times the number of all the human beings that have ever appeared on the earth. As one instance out of many of the im-

mense numbers of certain species of animals, we may mention what Mr. Wilson states, in his "American Ornithology," that a single flock of the migratory pigeon of the United States was found to be about a mile in breadth and two hundred and forty miles in length—having occupied four hours in passing across the country; which flock, by a moderate calculation, was estimated to contain two thousand two hundred and thirty millions, which is nearly three times the human population of the globe.

We may just further make the following statements in reference to the earth. In its course round the sun, it moves in an elliptical orbit, the longer diameter of which is 3,236,000 miles greater than the shorter, and consequently it is nearer the sun at one season of the year than at another. The time of its annual revolution is three hundred and sixty-five days, five hours, forty-eight minutes, forty-nine seconds, which is called the tropical year; but the time it takes in moving from a fixed star till it returns to it again is three hundred and sixty-five days, six hours, nine minutes, twelve seconds, which is called its sidereal year. With regard to the density of the earth, it is found to be about five times denser than water; so that could we suppose five globes as large as the earth composed of

water, suspended at one end of an immense balance, and the earth at the other, they would nearly counterpoise each other.

SECTION V.—*On the Moon.*

The moon is the nearest of all the celestial bodies to the earth, and is its constant attendant during its revolution round the sun. It belongs to that class of bodies called secondary planets, or satellites. A primary planet is one which revolves around the sun as its centre: a secondary planet is a body which revolves around a primary planet as its centre of motion, and is at the same time carried along with its primary around the sun.

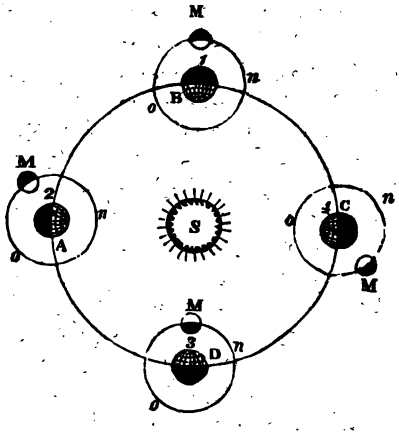
Motions of the Moon.—The moon has an apparent motion round our globe every day, somewhat similar to that of the sun. She rises in an easterly direction, and, after a certain number of hours, sets in the western quarter of the heavens; this motion is not real, but only apparent, and is caused by the diurnal motion of our globe from west to east. The real motions of the moon are as follow:—In the course of twenty-seven days, seven hours, and forty-three minutes, the moon makes a progress through the ecliptic, or round the whole heavens from

west to east, and returns to the same stars from which she set out. This is called her tropical revolution. The period of one new moon to another, or from one conjunction with the sun to another—which is twenty-nine days, twelve hours, forty-four minutes, and two seconds—is called her synodic revolution. The reason why these periods are different is this: at new moon, the sun and moon are in the same part of the heavens; but by the time the moon has returned to that point—namely, twenty-seven days, seven hours, forty-three minutes—the sun has proceeded, in his apparent course through the heavens, twenty-seven degrees further to the east, and is still going on, and the moon has to overtake him before she can be again in that position which is called new moon.

Fig. 33 exhibits some of the motions of the moon in relation to the earth and the sun. The small circle in the centre, S, represents the sun; the circle, A B C D, the earth's orbit, and the earth in four different positions. The smaller circle, M *n* σ, represents the orbit of the moon in its course round the earth. Around this orbit she moves, in a period somewhat less than a month, at the rate of 2,300 miles an hour. But while she is thus carried, monthly, around the earth, she is also carried forward along with

the earth, in its revolution round the sun. For example, while the earth has moved from B to A, the moon has made more than three revolutions round the earth, and at the same time has

Fig. 33.



moved, along with the earth, nearly one hundred and fifty millions of miles, or the fourth part of the earth's annual circuit; so that the moon's motion through space is much more rapid than that stated above, and cannot be estimated at less than seventy thousand miles an hour. When the earth is at B, in the posi-

tion marked I, and the moon at M, the enlightened side of the moon is turned to the dark side of the earth, and the moon is in the position we call full moon, the whole of its enlightened surface being then turned toward the earth. When the earth is at D, and the moon in the position marked 3, the dark side of the moon is turned toward the earth, and she is, consequently, invisible. This is the position of new moon. In the manner now described does the moon revolve round the earth, and is carried along with the earth round the sun, from one year and one century to another; and has done so ever since she was appointed to give light to the earth, and "to rule the night." And since she is acted upon by two forces—the attraction of the earth, and the attraction of the sun, which sometimes act in opposite directions—her motions are very irregular; which renders it somewhat difficult and tedious to calculate her precise position in the heavens at any particular moment of time.

Phases and general Appearances of the Moon.—The sun always enlightens one half of the moon; and sometimes the whole of this enlightened side is turned toward the earth, when she appears a round luminous orb: but this happens only in one point of her orbit. At all

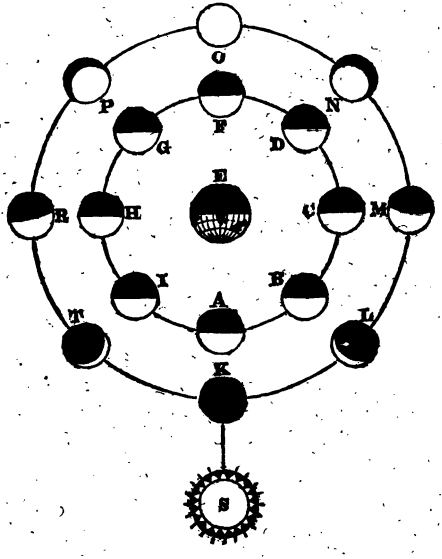
other parts of her course, only a portion of her enlightened hemisphere is seen from the earth; and in one particular position in her orbit her enlightened side is altogether invisible. When she is at the change, or the period of new moon, she is invisible; both because she is in the same part of the heavens as the sun, and because the whole of her dark hemisphere is then turned to the earth. After this it is generally two days, or more, before any part of her enlightened surface is visible. About the third day after the change, she is seen in the western sky, at no great distance from the point at which the sun set, and then appears under the form of a slender crescent, with its horns pointing toward the east. Next evening, about the same hour, she will have moved about thirteen degrees further to the east, and her crescent will appear to have increased somewhat in breadth. Every succeeding night she will appear to have moved still further to the east, while her crescent is still increasing in breadth and luminosity, till about the eighth day from the change, when she appears in the form of a half-moon. She is then about ninety degrees from the sun. After this period, still proceeding eastward, she assumes a gibbous phase, till she arrives at the period of full moon, when her whole enlight-

ened hemisphere is turned toward us; which happens on the fifteenth day after the time of the new moon, when she is in opposition to the sun, or one hundred and eighty degrees distant, and rises about the time when the sun sets. On a cloudless night she then displays to every beholder a delightful and magnificent spectacle, calculated to arrest the attention of every eye, and to inspire the soul with emotions of sublimity. But she does not remain long in her full-orbed lustre; she gradually loses a portion of her brightness, by presenting to us a part of her dark hemisphere. She again appears for a few days in a gibbous phase; afterward she assumes the appearance of a half-moon, and then that of a crescent, whose horns are now turned toward the west. In this position she is seen only in the mornings before sunrise; and, in a few days afterward, she is in conjunction with the sun, when her dark side is again turned toward the earth. All these changes are accomplished in twenty-nine days and a half.

These phases are more particularly represented in fig. 34, where S represents the sun, E the earth, and A B C D F G H I the moon in different parts of its circuit round the earth, with its hemisphere turned toward the sun fully

enlightened. When the moon is at A, its enlightened side being turned to the sun, its dark side is toward the earth, and were it then visi-

Fig. 34.



ble, it would appear as at K, in the outer circle; but it is never visible in this position, except at the time of an eclipse of the sun, when its body, either in whole or in part, interposes between

us and the sun. This is at the period of new moon. When the moon has moved from A to B, a portion of its enlightened surface is then turned to the earth, and it appears as a crescent, as represented at L; when arrived at C, the one half of its enlightened hemisphere is turned to the earth, and it appears in the form of a half-moon, as at M; when arrived at D, it presents a gibbous phase, as at N; and when arrived at F, it shines in all its splendor as a full moon, as at O. After this period it gradually declines first to a gibbous phase, as at P; next to a half-moon, as at R; then to a crescent, as at T; after which it arrives at its former position at A, the period of new moon; when it is again invisible.

How the Earth Appears to the Inhabitants of the Moon.—We have now seen the cause why the moon presents so varied appearances to the earth; let us now consider how the earth itself will appear as viewed from the surface of the moon. Could we take a view of the earth from one of the mountains, or plains, of the moon, we should find that it exhibits the same changes, or phases, that the moon does to us, but in a reverse order. For when, at new moon, the dark side of the moon is turned toward us, the whole of the enlightened hemisphere of the

earth is then turned toward the moon. And as the hemisphere of our globe is thirteen times larger than that of the moon, it will present in the lunar firmament a shining orb as large as thirteen of our full moons, and will, therefore, diffuse a considerable degree of lustre in the absence of the sun. That the earth shines with a full enlightened face upon the moon at the period now stated will appear from the preceding diagram, fig. 34. At A, the moon is in conjunction with the sun as seen from the earth, and its dark side is turned toward us; but it will be perceived that, at that time, the enlightened side of the earth, E, is completely turned toward the moon, so that, while she is invisible to us, our globe appears in its full-orbed majesty and brightness to the lunar inhabitants. On the other hand, when the moon is at F, when it is full moon to us, the dark side of the earth, E, is turned toward the moon, and is consequently invisible to the inhabitants of the moon, being then nearly in the same part of the firmament as the sun. When the moon is increasing to us, the earth is diminishing in its illuminated surface to the moon. When the moon is at B in its increase, the earth appears as at P; when she appears as a half-moon as at M, the earth appears a half-moon in the decrease, as at N;

and when she increases to a gibbous phase, as at N, the earth has decreased to a crescent, as at T; so that the phases of the earth, as seen from the moon, are exactly opposite to those of the moon as seen from the earth.

That the earth actually shines upon the moon, and illuminates its surface as the moon does that of the earth, is proved from the following circumstance. On the second or third day after new moon, when she appears as a slender crescent, we perceive a faint light on the dark part of the moon which is not enlightened by the sun, so that the whole hemisphere of the moon is visible—one part faint, and the other bright. This is perceptible even by the naked eye, but it appears pretty vivid through the telescope when a small power is applied, so that many of the principal spots of the moon may be distinctly perceived. This may be termed the "moonlight of the moon," as the earth is then shining upon its surface with nearly a full enlightened hemisphere. This light on the dark side of the moon gradually decreases, as the enlightened part of the moon increases, because the enlightened portion of the earth is at the same time diminishing, so that its effect is not much perceived after the period of half-moon. It has been sometimes observed that a brighter

reflection proceeds from the moon when the continental parts of the earth are opposite to her than when the Atlantic, or the Pacific Ocean, is in the same position. There is less light reflected from the sea than from the land upon the moon, and therefore it is natural to suppose that when the hemisphere of the earth, which contains Europe, Asia, Africa, and New-Holland, is shining upon the moon, a considerably greater quantity of light will be reflected on her surface than when the Pacific Ocean, which covers nearly half our globe, is directly opposite to her. In the course of the diurnal rotation of the earth every part of its surface in succession will be presented to the moon; and therefore it will appear to a lunar inhabitant with different degrees of brilliancy, at different times, arising from the circumstances now stated. (See fig. 31, p. 151.)

The moon always presents the same side to the earth, so that we never see its opposite hemisphere. This circumstance proves that she turns round her axis in the same time she takes to move round the heavens. If the moon had no motion round her axis, we should see both her hemispheres in the course of every revolution she makes round the earth. Whether the other side of the moon be less adapted for

reflecting light than that which is next us, or whether it be equally diversified with mountains, caverns, and plains, we have no opportunity of determining; though, reasoning from analogy, we may conclude that the arrangements of nature in that hemisphere are not essentially different from those we perceive in the hemisphere presented to our view.

There is a peculiar appearance which may be noticed, that the earth will present to an inhabitant of the moon, and it is this—that from any particular spot on the lunar surface, the earth will appear in a fixed position in the heavens, without any apparent motion. To those who live in the middle of the hemisphere next the earth, the earth will appear as a large globe in the zenith, or point directly above their heads, sometimes appearing as a half-moon, a crescent, or a full enlightened hemisphere, and sometimes invisible, but always in the same position. The only motion they will occasionally perceive is the earth's rotation, which they will observe as the different continents, islands, and oceans of our globe present themselves in succession. Those who live near the margin of the moon's hemisphere, next the earth, will see the earth near the horizon, and it will never appear from such places in a more elevated position in the

heavens. Those who live in intermediate positions will behold the earth at higher or lower elevations, according to their distance from the centre of the hemisphere. All these appearances necessarily result from the circumstance that the moon always presents the same side to the earth, and to account for such phenomena will be apt to puzzle the lunar astronomers. Hence, it necessarily follows that those who live on the opposite hemisphere of the moon will never see the earth nor enjoy its light. From the central parts of that hemisphere, an astronomer—who had heard of the remarkable celestial phenomenon to be seen in the other hemisphere—would have to travel more than one thousand seven hundred miles before he could see the earth emerging from the horizon; and in order to behold it in its full lustre, shining directly from the zenith, he would have to travel one thousand seven hundred miles further, or three thousand four hundred miles in all. We presume that there are few terrestrial astronomers who would grudge to undertake such a journey were they to behold a resplendent moon hanging in the vault of heaven in another hemisphere, which is altogether invisible in their native country. Sir J. Herschel, in order to explore the starry regions in the southern

hemisphere, undertook a voyage to the Cape of Good Hope, where he remained for years, and brought home some interesting pieces of intelligence from the starry regions.

Distance and Magnitude of the Moon.—The moon, though the nearest celestial body to the earth, is still at a considerable distance. This distance is reckoned to be, at a medium, about 237,000 miles, or about thirty times the diameter of our globe, which is determined from its horizontal parallax, or the angle formed by a line drawn from the centre, and another line drawn from the surface of the earth. As the moon, however, moves in an elliptical orbit, she is sometimes more than 240,000 miles distant, and sometimes considerably less than 237,000. Small as this distance is, compared with that of the other planets, it would require nearly five hundred days, or about sixteen months, for a steam carriage to move over the interval which separates us from the lunar orb, although it were moving day and night at the rate of twenty miles every hour. Although the apparent size of the moon is equal to that of the sun, yet the difference of their real bulk is very great; for it would require more than sixty-three millions of globes of the size of the moon to form a globe equal in magnitude to that of the sun. The

reason why the sun appears so small, when he is in reality so large a globe, is this—that he is removed ninety-five millions of miles from the earth, which is nearly four hundred times further than the moon. The diameter of the moon is two thousand one hundred and eighty miles, which is little more than the fourth part of the diameter of our globe, and consequently, in point of solidity, it is only the forty-ninth part of the bulk of the earth. Its surface, however, contains fifteen millions of square miles, or about one-third of the habitable regions of our globe; and were it peopled as densely as England, it would contain a population amounting to four thousand two hundred millions, which is more than five times the population of the earth. The circumference of the moon is six thousand eight hundred and forty-eight miles, and, therefore, if a railroad were formed around it, its inhabitants could travel completely round their world in the course of fourteen of our days, at the rate of twenty miles an hour; and the journey could be so arranged that they might enjoy uninterrupted moonlight from the earth in one part of it, and uninterrupted sunlight during the other—an advantage which we can never enjoy in our terrestrial region.

Telescopic Appearance of the Moon.—When

the moon is viewed with a good telescope, the lunar surface presents a very interesting and diversified appearance. Mountains and plains, caverns and insulated rocks, hills and plains of almost every shape, diversify every portion of the surface of the moon. It is evident, almost at first sight, that the moon is diversified with

Fig. 35.

inequalities of surface, and has lofty eminences and deep vales, when we view her surface with a powerful telescope, when she appears in the form of a crescent, or of a half-moon; for then we perceive the boundary between the dark and enlightened side—not a straight line or a regular

curve, as it would be if the moon were a smooth surface—but jagged and uneven, somewhat like the edge of a coarse saw. Within the dark portion of the moon, adjacent to this boundary, bright points appear, somewhat like stars, which are evidently the higher tops of the lunar mountains, enlightened by the sun before his rays can reach the valleys, just as we find that in our globe, when the sun is rising, his beams gild the mountain tops, while the plains and valleys are still in the shade. Shadows of different dimensions, too, are to be seen in various parts of the enlightened portion of the moon, indicating both elevations and depressions.

The mountainous regions of the moon are arranged in a very different form from those of the earth. There are, indeed, some mountain ranges on the lunar orb somewhat resembling our Alps, and Apennines, and Andes; but one of the distinguishing features of the moon consists in hundreds of circular ranges of mountains surrounding plains of the same shape. The following are a few of the characteristic features of the lunar surface:—1. Plains of various extent and peculiarities. Some of these plains are more than one hundred miles in diameter, or in length and breadth. These present a darker and more sombre appearance to the eye

than the other parts of the lunar surface, and, in many instances, they contain, here and there, deep cavities. They were formerly considered as seas, or large collections of water, but there appears no evidence that seas, or any large collection of waters, exist on the surface of the moon. Besides these large plains there are numerous circular plains of a lesser size, of all dimensions, from two or three miles to thirty miles in diameter, surrounded with a circular ridge of mountains, as with a wall or rampart. These are to be found in most regions of the moon, and they form a peculiar feature of her surface, altogether different from what obtains on our globe. 2. The moon displays a great variety of mountain scenery. In the first place, there are chains of mountains, which run in a right lined direction, not altogether unlike those which exist on our globe. The most remarkable range of this kind is that called the Apennines, which traverses a portion of the lunar disk from the north-east to the south-west, which may be seen to advantage about the time of half-moon, and a day or two afterward. It rises with a precipitous and craggy front, from a large plain called the *mare imbrium*, extends to a great length, and, in some places, rises to the perpendicular height of four miles. This is

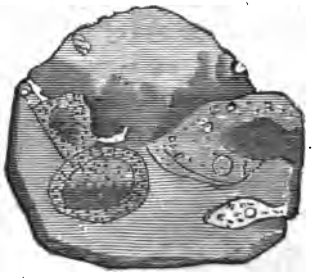
most precipitous on the side of the plain, and gradually slopes off with its hundreds of peaks to the opposite declivity, resembling in some degree our Andes and Himalayas. In the next place, there are insulated mountains, or peaks, or mountains in the shape of a sugar loaf, which rise directly from the plains, and are altogether unconnected with any ridge or group whatever. Some of these are several miles in perpendicular altitude, and their shadows thrown opposite to the sun are as distinctly seen through the telescope as the shadow of a gnomon on a sun-dial. They bear a certain resemblance to the Peak of Teneriffe, and Adam's Peak in the Island of Ceylon. But in the third place, the chief features of the mountain scenery of the moon consist in those circular ranges of mountains which occupy nearly one-half of the lunar surface, and are dispersed in all directions. In some cases, they appear like a wall of sixty, one hundred, or one hundred and fifty miles in circumference, surrounding circular plains of corresponding extent. In other cases, they are from five to ten or twelve miles in diameter; and in many instances there is a central mountain of considerable elevation, which rises from the centre of the circular plain. There is nothing similar to these arrangements

in any part of our terrestrial system. The lunar mountains, according to Schroeter's measurements, are of all sizes, from three hundred feet to five miles in perpendicular height. 3. Another singular feature of the moon's surface consists in those numerous depressions, or cavities, which appear on almost every part of her disk. These cavities are circular, and bear a certain resemblance in shape to an egg cup. A high annular ridge, marked with lofty peaks and small cavities, generally encircles them, an insulated mountain frequently rises in the centre, and sometimes they contain smaller cavities of the same nature as themselves. These hollows are most numerous in the south-west parts of the moon, and from this cause it is owing that that portion of the lunar surface is more brilliant than any other portion of the moon; these cavities, along with the mountainous ridges which encircle them, reflecting a greater quantity of light than any other part of the lunar regions. As to their dimensions, they are of all sizes, from three miles to fifty miles in diameter at their orifices, but they generally decrease in breadth toward the bottom. Their depth varies from about one-third of a mile to three miles and three quarters below the summits of the mountains which surround them; but in all

cases the internal depth of the cavity is much lower than the general surface of the moon. Of this feature of the lunar surface we have no examples in any part of our globe; but we have reason to believe, from the variety which exists in nature, that not one world in the universe exactly resembles another it its particular arrangements.

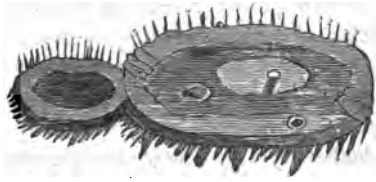
The following figures will perhaps convey a rude idea of some of the objects on the lunar surface now described. Fig 36 is a view of

Fig. 36.



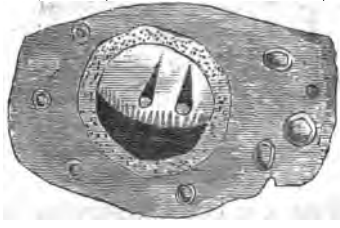
the brilliant spot called Aristarchus, which is situate in the north-east quadrant of the moon's surface, where the shadows of some of the circular cavities and also the shadows of the mountains may be perceived. Fig. 37 is the spot called Hevelius, which contains an annular cavity, and a broken elevation somewhat re-

Fig. 37.



sembling an egg. Fig. 38 represents a cavity surrounded by a circular range of mountains, with two central mountains in the middle of the plain, in which the shadows of one side of the circular range and of the central moun-

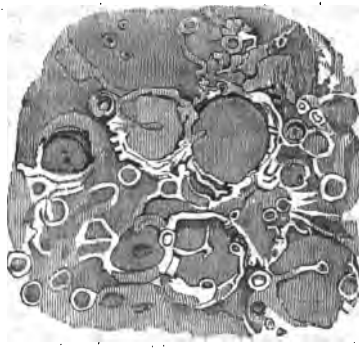
Fig. 38.



tains may be seen. Fig. 39 shows another magnified portion of the moon's disk, exhibiting several circular plains, cavities, and other varieties of the lunar surface.

From what we have now briefly stated, it is evident that an immense variety of picturesque

Fig. 39.



and sublime scenery is presented to view on the surface of the moon, and could we conceive ourselves standing on some of her lofty peaks, her circular mountain ridges, or on the summit of her central mountains, we should behold a much greater extent of prospect, and an assemblage of more grand and sublime objects than is presented to our view in any of our terrestrial landscapes. The best time for viewing all the varieties of scenery on the moon's surface, with a telescope, is about the period of half-moon, or two or three days before or after it, at which times the shadows of the lunar mountains and cavities are longest and most distinct. At the time of full moon, many

of the objects described above cannot be perceived, as the sun then shines perpendicularly upon the moon's surface, so that the shadows of the different objects cannot be distinguished. The following additional particulars respecting the moon may be stated.

1. The length of a lunar day is equal to nearly fifteen of our days, and the length of the night the same, so that a day and night in the moon are equal to twenty-nine days and a half, or one lunar month. On the hemisphere next the earth, there is moonlight nearly all the time the sun is absent; but in the other hemisphere, in the absence of the sun, there is no light but what proceeds from the stars and planets. Were a lunarian to travel, at the rate of ten miles an hour, in a direction at right angles to the moon's axis, he might keep pace with the moon's rotation, and be enabled to live in perpetual sunshine. 2. The light of the moon has been computed to be 300,000 times less intense than that of the sun, when shining in an unclouded sky; yet its utility is considerable, and when the full moon shines in its splendor, it throws a cheerful, though mild light over the surrounding landscape. 3. The nearer the moon is to the periods of new and full moon, the greater is her velocity in her orbit; and the

nearer she is to the quadratures, the slower she moves. When the earth is in its perihelion, or nearest the sun, which happens in winter, the periodical time of the moon is greatest; and when the earth is in its aphelion, which happens in summer, the periodical time of the moon is the least. 4. The mean inclination of the moon's orbit to that of the earth is five degrees nine minutes. 5. The eccentricity of her orbit is 12,960 miles. 6. The moon in all probability is surrounded with an atmosphere, but it is evidently a very small one, and of extreme tenuity; and no clouds or vapors appear to exist in it. It is stated as having been distinctly perceived during the annular eclipse of May, 1836, when, just before the rims of the two bodies met, the light of the sun was seen to shoot through the moon's atmosphere, mollified into twilight. Schroeter calculates its height at 5,742 feet.

There can be little doubt that the moon, like the earth on which we dwell, is a world replenished with inhabitants. Matter appears to have been created chiefly in subserviency to mind; and it is highly improbable that the Creator would leave a globe containing a surface of fifteen millions of square miles together destitute of sensitive and intellectual beings,

especially when we behold its surface diversified and adorned with such a vast assemblage of picturesque and sublime scenery, and when we consider that every department connected with our globe is peopled with sentient beings of every description. Although seas and rivers and a dense atmosphere are not to be found connected with the lunar orb, and although some of its arrangements are different from those of the earth, yet these circumstances form no valid objection to the moon being inhabited, for the Creator can, in all cases, adapt the inhabitant to the nature of the habitation provided for him, as he has adapted the birds for winging their flight through the air, the fishes for gliding in the waters, and man and quadrupeds for traversing the dry land.

It has frequently been a subject of inquiry, whether the inhabitants of the moon may ever be discovered by the inhabitants of our globe? Notwithstanding the improvements that have been made on telescopes in modern times, we have no expectations that such a discovery will ever be made. Even the large telescope lately constructed by the earl of Rosse, however distinct and beautiful a view it may exhibit of the mountains and vales, rocks and caverns, on the lunar surface, will never be able to show

us its inhabitants, although they had bodies five hundred times larger than those of the inhabitants of the earth. That telescope has seldom been used with powers exceeding eight hundred times; but although a power of two thousand times could be put upon it with distinctness, it would make the moon appear no nearer to us than one hundred and twenty miles, at which distance a living being, although a hundred feet high, could not be beheld. For, with such a power, a space on the moon's surface one hundred and eighty-three feet in diameter could only be perceived as the smallest visible point. Besides, we ought to consider that when we view objects on the surface of the moon, we do not view them in perspective, as we view objects on the surface of the earth, but only obtain a bird's eye view, as we do of objects on the surface of our globe when viewed from a balloon suspended in the atmosphere, in which case when we look down upon a group of human beings, we perceive only the length and breadth of their heads and shoulders.

There is a possibility, however, of tracing the operations of sensitive, or intelligent beings, in the lunar orb, although we can never expect to trace the forms or motions of its inhabitants. Were a vast number of persons in different

parts of the world to devote themselves to a particular survey of the moon—were different portions of its surface allotted to different individuals as the object of their particular research —were accurate observations made, and frequently repeated, on every mountain, hill, cavity, cliff, and plain, and every change and modification in the particular spots and their localities carefully marked and represented in a series of delineations, it might lead to some certain conclusion both as to the physical constitution of the moon, and as to whether any of the observed changes proceeded from the operations of living agents. If an observer in the moon, with such a telescope as Sir William Herschel's, or that of the earl of Rosse, had observed the city of Babylon, when in its splendor, and afterward when reduced to a desert, as it now is, he must have observed a change in the locality where that famous city once stood, indicative of the operations of intelligent, or, at least, of sensitive, or living agents. And had he viewed the dense forests of America before civilized nations took possession of that country, and were he now to take a view of the eastern states of North America, in their present state of cultivation, and since the great cities of New-York, Boston, and Philadelphia were reared, a striking difference

between the present and the former state of that country would, doubtless, be perceptible. For, if an extent of only one hundred and eighty-three feet, or sixty-one yards, would be perceptible by a telescope magnifying two thousand times, much more would the extent of a large city, such as New-York, be distinctly visible, as a prominent and well-defined object. Now, if changes, similar or analogous to these, could be traced on the surface of the moon, it would lead us to form some certain conclusions in relation to the operations of intelligent agents, and consequently, that such beings actually exist on the lunar surface. But such observations as those to which we allude would require not only to be specific and minute, but also to be continued for a length of years—perhaps a century or more—before any striking changes could be expected to occur.

Dr. Olbers was fully of opinion, from the observations he had made, "that the moon is inhabited by rational creatures, and that its surface is more or less covered with a vegetation not very dissimilar to that of our earth." It has formed a subject of speculation with some, whether it might be possible to correspond with the lunar inhabitants by symbolical representations. If they be mathematicians, it has been

conceived that the erection of geometrical figures on some extensive plains on our globe, on a scale of vast extent, might be recognized by the inhabitants of the moon, as a signal of correspondence, and that they might erect similar figures in return. But it is highly questionable whether the design of such figures would be appreciated, or whether they would be visible to the eyes of the inhabitants. Many a look, we may conceive, will be directed to our globe by the lunar inhabitants, and much wonder will doubtless be expressed at such a large globe hanging over their heads, apparently immovable, excepting a rotation round its axis; and much speculation will, without question, take place among them as to whether such a globe as ours be inhabited. But it does not appear to be the design of the Creator, in the mean time, that the inhabitants of our globe and those of the moon should become acquainted, or that any direct correspondence should take place between different worlds. And, therefore, we must wait with patience till the scenes of a future life shall unravel the mysteries, and dispel the darkness which now hangs over the history, the population, and the transactions of other worlds. Whatever may be the peculiar circumstances of the beings that people other

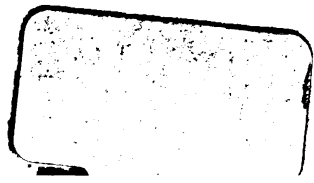
globes, we know that they are all under the care and superintendence of Him who is infinite in wisdom, power, and intelligence; whose "kingdom ruleth over all," and whose "tender mercies are over all his works."

But, whatever opinions we may entertain respecting the inhabitants of the moon, certain it is that she forms a beautiful and noble appendage to our globe, and her light and motions are of high utility to its inhabitants. How cheerless and uncomfortable, in many cases, would be our nights, were it not for the mild radiance which the lunar orb dispenses in such regular and agreeable vicissitude! To the mariner, while ploughing his course through the stormy deep; to the ploughman, "plodding his weary way;" to the peasant, pursuing his course through moors and mosses after night-fall; to the shepherd, tending his fleecy charge by night; to travelers in foreign lands; and to the missionary in pagan countries, when returning at midnight from his sacred labors; the moon, in her various stages, is always a most cheerful and welcome visitant. She throws a mild and silvery lustre over the forests, the mountains, and the vales, and we behold a new picture of terrestial objects, which is more delicately shaded, and disposed into softer lights than that which

is displayed under the blaze of the meridian sun—a scene which leads the pensive mind to pleasing reflections, and to solemn contemplation. By her attractive influence, she sways the ocean, and perpetuates the regular returns of ebb and flow, by which the liquid element is preserved from putrefaction, and the inhabitants of the islands and continents from infection and disease. And although her brightness is not the same at all seasons, and though she is sometimes absent from our nocturnal hemisphere, yet, in her absence we enjoy, on a clear evening, a more extensive prospect of the starry regions, and of those remote spaces of creation, where suns unnumbered shine, and comets run their solemn rounds. Let us then be grateful to our beneficent Creator, who in this, as well as in all his other works, has displayed his infinite wisdom and his unbounded goodness; and let us, in unison with the inspired writers, praise the name of the Lord, who hath appointed "the moon to rule by night," as an evidence of his fatherly care, and of his mercy, which "endureth for ever."

END OF PART I.

Coolly Minimes 5.



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S. J. BOOK.

IDENCE. L. M.

Through ev - ery pow'r my soul hath